STANDARD
NATURAL HISTORY

EDITED BY J. S. KINGSLEY

LOWER VERTEBRATES.

H. C. BUMPUS.
THEODORE GILL, Ph.D.
E. D. COPE, Ph.D.
D. S. JORDAN, Ph.D.
S. W. GARMAN.
J. S. KINGSLEY, D.Sc.
R. RAMSAY WRIGHT.

Rana catesbiana, bull-frog.

THE STANDARD

NATURAL HISTORY.

EDITED BY

JOHN STERLING KINGSLEY.

VOL. III.

LOWER VERTEBRATES.

Illustrated

BY TWO HUNDRED AND SEVENTY WOOD-CUTS AND SIXTEEN FULL-PAGE PLATES.

Boston:

S. E. CASSINO AND COMPANY.

1885.

C. J. PETERS AND SON,
STEREOTYPERS AND ELECTROTYPERS,
145 High Street.

CONTENTS.

LIST OF PLATES.

NATURAL HISTORY OF VERTEBRATES.

Branch VIII.—VERTEBRATA.

A very direct and personal interest attaches to the study of the Vertebrata, that branch of the animal kingdom to which man himself belongs, and of which he is in many respects the highest member. Many of the most interesting problems connected with man's place in nature can only be intelligently approached if the student is possessed of a certain degree of acquaintance with the structure of the animals built upon the same fundamental plan as himself. There can therefore be no more fitting introduction to the special description of structure and habits of the various groups of vertebrates than an attempt to indicate the anatomical features which are common to all, and the chief lines of modification of them. The object of the following pages will thus be to afford the reader some general stand-points, from which he may view the details embodied in the description of the separate groups, and at the same time to indicate the directions in which anatomists are at present working.

Since the appearance of Darwin's origin of species, a quarter of a century ago, a flood of light has been shed on comparative anatomy, by the labors of those anxious to test the applicability of the doctrine of evolution within the domain of their special researches. However far we may still be from the solution of the question how and why the series of animal forms at present on the earth's surface differ from those of past geological periods, the general consensus of opinion is that they have descended from them. It is impossible, within the scope of the present work, to present in a connected form the evidence on which this opinion is based; but the description of structure and development, as well as of the fossil forms, having been prepared in the light of the evolution theory, will render it an easy matter for the reader to discover their bearings upon that doctrine. Thanks to the immense quantities of fossil vertebrates obtained from this country, the paleontological evidence for the theory of evolution is more complete of information in this branch than in any other; and thus the systematist, having regard to these different sources, is enabled, by the construction of genealogical trees, to indicate near or remote kinship, and to illustrate, as far as can be done from our imperfect knowledge, the phylogeny or line of development of the various groups.

Since Lamarck, in the beginning of this century, first drew a sharp distinction between animals with and without backbones, the use of the terms vertebrate and invertebrate has become almost a part of popular language. Just as, however, the zoologist is obliged to restrict his use of the term fish to a narrower than the popular sense, so the advance of knowledge has led him to recognize affinities which oblige him to extend the term Vertebrata further than its etymology would justify. The conception embodied in that term is of animals possessed of a backbone formed of joints—the 'vertebræ'—having a certain amount of motion on each other. In the

sense that we shall employ the term, however, animals are included with no outward resemblance to the higher vertebrates, and, indeed, so unlike, that their affinities were for a long time doubtful, till these were rendered plain by the study of development.

All of the members of this great branch of the animal kingdom are characterized by the possession of a cellular cord — the notochord — which runs underneath the central nervous system, and which, in the higher forms, is surrounded by the permanent vertebral column and skull, and largely obliterated by the development of these structures. So the term CHORDATA is frequently employed as synonymous with Vertebrata in its wide sense. In most Chordata, the anterior end of the central nervous system is dilated into a 'brain,' and this acquires a protective capsule, the 'skull'; but these structures are absent in the two lower divisions of the branch, which are consequently known as ACRANIA, in contradistinction to the CRANIATA.

Our introductory account of the structure of vertebrates will be confined to the craniate division; for, both as far as numbers and morphological interest go, this is overwhelmingly the most important. Of course a large amount of interest attaches to the acraniate forms, in view of the consideration that all vertebrates are descended from an acraniate stock, but the Acraniata that have persisted to the present day are unquestionably not in the direct line of descent, and one of the divisions has only been able to hold its own in the struggle for existence by virtue of a remarkable series of degenerate specializations. The reader is referred to the special account of these divisions for details with which to compare the description of the structure of the craniata which follows. It need only be premised that the two divisions of acraniata are distinguished from each other by the relations of the notochord. In the single form, Amphioxus (Fig. 54) which constitutes the division Cephalocorda, the notochord is continued as far forward as the anterior end of the head, while the Urochorda, embracing all the animals known as Tunicates, pass through a tadpole-like larval stage in which the notochord is confined to the tail (Fig. 47). The fact, already indicated, that the Urochorda undergo a degenerate metamorphosis, their affinities with higher forms being chiefly observable during larval life, is sufficient to account for the much greater departure exhibited by their adults than by Amphioxus from the ordinary vertebrate type.

It will appear from the above what great prominence is now given by zoologists to the value of affinities revealed by the study of development. To the same branch of investigation are due many of the gigantic strides made by the science of comparative anatomy within recent years. To enable the reader to understand the direction of these, as well as to realize that embryology is often the only clue that can be relied upon to guide the student through the intricacies of adult structures, it is desirable at this stage to explain something of the processes by which the complex multicellular body is evolved from the apparently so simple unicellular egg. In describing the different systems of organs which compose the vertebrate body, further reference will be made to the mode in which these arise from the different layers of embryonic cells, even to the extent of repeating some of the statements given in the first volume of this series.

Before advancing to this part of our subject, it will be well that the reader should be acquainted with some of the morphological terms employed in the description of the vertebrate body. Much confusion has been occasioned by importing into comparative anatomy terms employed in human anatomy, but the efforts of Owen, Huxley, and others to introduce terms of general applicability to vertebrate animals have

resulted in a great improvement of anatomical nomenclature. These efforts have been ably forwarded by Professor Wilder in this country, with whom several of the terms employed here, especially in the description of the anatomy of the brain, originated.

Vertebrates are described in the ordinary prone attitude; the upper surface is the dorsal aspect; the lower, ventral; the sides, lateral; the extreme front end is the cephalic extremity; the tip of the tail, the caudal extremity. Their bodies are composed of symmetrical halves, disposed right and left of a mesal sagittal plane; *i. e.*, a vertical plane which joins the middle line of the dorsal and ventral surfaces from the cephalic to the caudal extremity. Frontal planes pass from dorsal to ventral aspects at right angles to sagittal planes. Horizontal planes cross from side to side at right angles to both. Direction towards particular aspects of the body is indicated by the adverbial termination 'ad;' thus, dorsad, cephalad, mesad. The symmetry of the vertebrate body is disturbed by the intestinal organs, but it extends to the paired limbs, anterior and posterior, which are generally present. Unpaired limbs (median fins) are only present in aquatic forms.

Certain of the systems of organs are disposed in segments, or metameres, one after the other. It is not uncommon that contiguous metameric parts should be fused with each other in such a way as to render it difficult or impossible to detect the segmentation. In comparing such segmental or metameric parts, they are said to be homodynamous, while parts which are developed the same way in different animals are homologous with each other, and structures which merely discharge the same functions are called analogous.

The intestinal organs show no trace of being disposed in metameres, unless the gill clefts and homologous structures are thus interpreted; and the same is true of the urinary and reproductive organs, with the reservation that segmental structure is indicated in the development of the former of these, and may be traced in the adults of lower vertebrates.

With extremely rare exceptions, the sexes are separate in vertebrates; except in Tunicates no asexual reproduction such as is met with in many of the lower branches occurs, and new individuals are consequently always developed from fertilized eggs. The fertilization of the egg is effected by sperm-cells formed in the testes of male individuals, while the eggs themselves are formed in the ovaries of females.

The development of the egg takes place either entirely outside the body of the mother, when the animal is said to be oviparous, or to a greater or less extent within the body of the viviparous mother.

Although in different groups we find the eggs as they leave the ovary to be widely different in size, yet they are always single cells. In the craniate vertebrates, the largest eggs are those of the birds, the smallest those of the higher mammals. In the latter group the ovarian egg measures about $\frac{1}{125}$ of an inch in diameter, the part of the sperm-cell which fuses with it in the process of fertilization hardly so much as $\frac{1}{5000}$, so that it is from the conjugation of two quite microscopic elements that the adult body results. In view of the facts of heredity, it is safe to say that the simplicity of the structure of the reproductive elements is only apparent, and that, although unicellular, they are still, in virtue of their molecular constitution, epitomes of the structure of the adults.

The sperm cells are always of small size, but the eggs may be very large, in virtue of having within the egg-membrane a greater or less quantity of 'food-yolk' in addition to the formative yolk, which is directly converted into the tissues of the embryo. Further nutritive material, like the white of the bird's egg, may be furnished by the

walls of the oviduct as the egg escapes to the outside; the lower part of that tube may also provide a protective shell for the egg, the form, texture, and chemical nature of which present wide differences in the various groups of oviparous vertebrates.

Eggs which are free of food-yolk, like those of most mammals, divide completely into two equal parts after fertilization, and this division goes on regularly till a mass of small cells results, which eventually arrange themselves into the three embryonic layers. Such eggs are holoblastic; but the presence of a large amount of food-yolk in the egg brings about various complications; it prevents the eggs dividing completely, and consequently the process of segmentation is limited to one pole of the egg, and is on this account styled meroblastic. Other processes, too, are rendered more complex by the presence of the mass of non-segmenting food material, so, as an introduction to the phenomena of development, we shall select the eggs of the toad, which are comparatively free from food material, and which divide completely, though unequally. The eggs of most mammals are so free from food-yolk that they divide completely and equally, but as the mammals are, probably, descendants of forms with large eggs, the loss of the food-yolk is to be considered as secondary, and as consequent upon the development of certain other arrangements (the placenta) for nourishing the embryo, which have rendered the other food material unnecessary. But the mammalian eggs have inherited from these earlier types certain complications which render it easier for the beginner to understand the processes of development in the eggs of frogs and similar forms.

As is well known, the spawn of toads and frogs is composed of groups of eggs surrounded by a transparent jelly-like mass, which, like the white of the bird's egg, is secreted by the walls of the oviducts, but, unlike that, is not used as food by the developing embryos. The egg itself measures about $\frac{1}{15}$ of an inch in diameter, and that pole which contains the nucleus or germinal vesicle is always more pigmented than the other. After fertilization the egg becomes completely divided into two equal parts, and very soon thereafter into four cells, two of which are much smaller than the others (Fig. 1). Even at this stage the cells begin to retract from each other, so as to leave a small space between them, which eventually increases as the division of the cell goes on, and becomes the segmentation cavity. The larger cells, which contain the food-yolk, segment more slowly than do those at the other pole of the egg, so that, before the next important stage in development takes place, a spherical multicellular body results, the cells at one pole of which are very much smaller than those at the other pole. At one spot on the line of junction of the small and large cells (Fig. 2, x), the small cells are turned in, or invaginated, so as to form the lining of a new cavity, the beginning of the intestine, and simultaneously, while the rest of the small cells gradually grow over the large ones so as to occupy also the other pole of the egg, the lining of the intestine becomes separated from the outer layer by a new middle layer, which grows round from the lips of the orifice of invagination (Fig. 2, m, m') In this way the three layers of the embryo are formed, to which all the tissues and

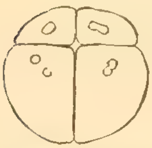


Fig. 1.—Egg of *Bombinator* after second segmentation.

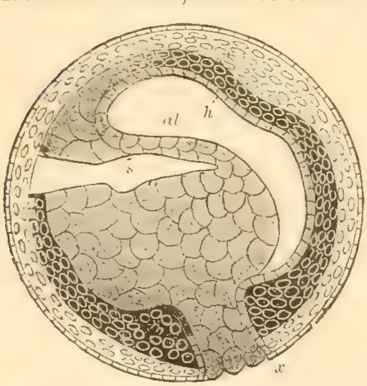


Fig. 2.—Diagrammatic longitudinal section of embryo toad; e, epiblast, h, hypoblast, m, mesoblast, s, segmentation cavity, x, edge of invagination.

organs of the body may be traced, viz: epiblast, mesoblast, and hypoblast. Of these, the former is constituted by the outer small cells, which now encase the whole embryo; the latter lines the intestine and draws upon the larger yolk-laden cells, as additions to the layer are required, while these two layers are separated by the mesoblast, which, in its development, is closely connected with the invagination of the intestine.

Although this orifice of invagination, or blastopore, is very much restricted in extent in the frogs, it would seem to have been much longer in earlier forms, for it is still represented in some amphibians as a 'primitive groove,' which extends along the dorsal surface of the egg, — that afterwards occupied by the central nervous system. Again, in some tailed amphibians the intestine retains, permanently, a communication with the outside through the blastopore, which is converted into the anus, and it is possible that this communication may have been double in earlier forms; a mouth persisting at the front end of the elongated blastopore, while the intervening part of the slit became closed. Neither slit nor groove are to be detected in the frog, but along that surface which is thus occupied in other forms, the epiblast becomes altered into a series of cells, which, at first, form a flat plate on the level of the other epiblastic cells, but afterwards come to lie in a groove below that level. These altered epiblastic cells are destined to form the central nervous system. The groove is known as the medullary groove; in the middle of its extent it soon becomes converted into a tube, so that the resultant nervous tube or canal then communicates with the outside merely by an anterior and posterior neuropore. During the closure of the medullary groove, which is illustrated by a transverse section of an embryo newt in Fig. 3, the epiblast, which was at the sides of the groove, comes to lie over it, and a seam is thus formed along the middle line above, all traces of which are, however, very soon obliterated.

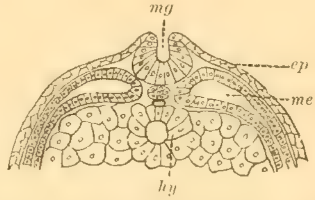


FIG. 3.—Transverse section of embryo newt; *e*, epiblast; *hy*, hypoblast; *me*, mesoblast; *mg*, medullary groove.

It is very probable, as has been suggested by Sedgwick and Van Wijhe, that the stage of development we are considering now, where the neural tube is open in front and behind, really answers to an ancestral vertebrate form, where both intestine and neural tube were traversed by streams of water sucked in by the ciliated linings of these canals. The anterior neuropore is only very transitorily open, however (except in Amphioxus, where, even in the adult, such a stream enters the neural tube), but the posterior neuropore retains for some time after that an intimate relation with the blastopore (Fig. 4), or when that orifice closes, as it does in the case of the toad here described, with the neighboring part of the intestine, so that a canal of communication between the neural and intestinal tubes (neurenteric canal) exists for some time. That rudiments of this canal are met with also in the embryos of birds and mammals is strong evidence of the truth of this hypothesis.

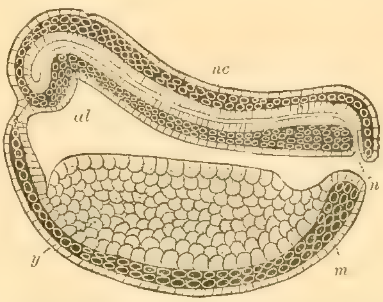


FIG. 4.—Diagrammatic longitudinal section of embryo toad; *al*, alimentary tract; *nc*, neural canal; *m*, mesoblast; *y*, hypoblast; *n*, neurenteric canal.

So far the intestine of the embryo toad only communicates with the exterior by the blastopore, but, when that closes, a new aperture, the anus, is formed further for-

wards, and the part of the intestine behind the anus, as well as the neurenteric canal, soon become obliterated. It is at a late stage that the intestine acquires a new opening to the exterior, the mouth (Fig. 5), which is formed by the turning in of the epiblast towards the front end of the intestine. In this way a complete intestinal tube is established.

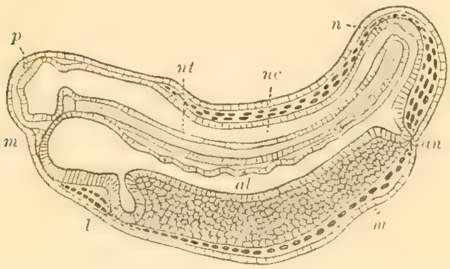


FIG. 5.—Longitudinal section of *Bombinator* embryo; *an*, anus; *nt*, notochord; *l*, liver; *m*, mouth; *nc*, neural canal; *p*, pineal gland; *al*, alimentary canal; *n*, neurenteric canal.

While these changes in the neural and intestinal tubes are going on, important alterations are likewise taking place in the mesoblast. This layer is not continuous underneath the neural tube, but is divided into a right and left half (Fig. 4), separated by the notochord, itself probably derived from the underlying hypoblast. It is important that the student should understand the relationship of the mesoblast to the notochord at this stage, as it is round the notochord that the important axial skeleton is eventually formed. At present each sheet of mesoblast is plainly formed of two strata, Fig. 3, the outer of which applies itself to the epiblast, the inner to the hypoblast. The space between the two is the future cavity of the body in which the viscera lie; higher up the space dilates considerably in the parts of the mesoblastic sheets lying alongside the notochord, and eventually a complete separation is effected between these upper and lower parts. The upper parts become divided into a number of cubical segments, arranged in pairs on either side of the notochord; these retain their original cavity for some time, and give rise to certain very important organs. They are known as protovertebræ, or, better, as mesoblastic somites, and are the first indication that the frog is a segmented animal. The lower parts of the mesoblast, or lateral plates as they are now called, remain undivided into segments.

All of the processes above described, as well as others to which no reference has been made, take place while the embryo is still encased in the egg-membrane. After that membrane has been burst, the embryo escapes and swims about as a tadpole, which still differs from the adult by the presence of a fish-like tail, the absence of paired limbs, and the fact that respiration is conducted by external gills instead of by lungs. The change to the air-breathing adult stage (so great that it is called a metamorphosis) is effected by the loss of the tail and gills, and the development of the legs and lungs.

It is by processes similar to those described in the frog that the unicellular egg of all vertebrates is converted into an embryo in which three distinct layers of cells are present, destined to give rise to all the organs of the body. These layers are arranged relatively to each other in such a way that the epiblast which covers the whole body has already given rise to a dorsal nervous tube, separated by the notochord from the primitive intestine, while the mesoblast, situated between the other layers, has separated dorsally into the metameric cubical somites, while ventrally it splits into two plates, which adhere to the epiblast and hypoblast respectively, leaving between them the body-cavity.

These processes have only been described so far as to make intelligible the mode of origin of the different systems of organs, to the account of the general arrangement of which we now proceed. They are generally discussed in the following order: the

skin, the skeleton, the muscular and nervous systems, the intestinal, respiratory, vascular, and urogenital systems.

The Skin in Vertebrates.

As we shall presently see, there is considerable difference in the structure of the skin in the aquatic and the air-breathing vertebrates, but both groups agree in the fact that it is invariably composed of two primary layers, the 'epidermis' and the 'corium.' The former is derived from the epiblast of the embryo, while the latter is formed from the most superficial stratum of mesoblastic cells. Fig. 6 represents diagrammatically a section through the skin of a fish, in which the two layers are very distinctly seen. In the epidermis we observe that those cells which are closest to the surface are more or less flattened, while those resting on the corium are much more elongated. The cellular structure is always easily recognizable, the individual cells being separated by chinks which are traversed by connecting bands of protoplasm. Occasionally a branched pigment-cell may be seen thrusting its processes into these inter-cellular chinks. Certain of the surface cells are constantly being transformed into mucus-cells, which, becoming larger than their neighbors, and undergoing a chemical and physical change, eventually burst and discharge their mucous contents on the surface of the skin. In those fishes, like the eel and cat-fish, where the skin is particularly slimy, this is no doubt due to the abundance of certain very large 'clavate' cells, which pour out their secretion into the intercellular spaces. Such clavate cells are known in the common mud-puppy and other aquatic Amphibia, but they disappear from the skin with the change to a new element in cases like the salamander, which, after a larval aquatic life, become, when adult, wholly terrestrial in their habits. As for the mucus-cells, they also do not occur in the skin of air-breathing animals, although they are abundant in the cavity of the mouth.

The epidermis and corium are not in contact with each other by a perfectly flat surface, but the latter is here and there elevated into 'papillæ,' in which the looped capillary vessels are found, whence the nourishment of the epidermis is obtained, and through which the nerves which are destined for the epidermis course. Below this papillary layer, which is further generally remarkable as a seat of pigment cells, the corium is formed, in the aquatic vertebrates, of parallel bands of fibres, traversed here and there by a stout bundle conveying outwards vessels and nerves. Separating this comparatively dense layer from the underlying muscles, is a varying amount of looser connective tissue, often rich in fat, which is termed the 'subcutaneous connective tissue.'

In many respects the epidermis of aquatic vertebrates is a higher and more complex organ than that of the air-breathing forms. This is especially true of modified tracts of the epidermis, which are developed at the extremities of nerves, and which are on this account known as 'neuro-epithelial' structures. Two varieties of these exist in the skin; one, on account of its shape and its relation to a nerve, is known as an 'end-bud,' and such end-buds, carried upon papillæ, are extremely common over the whole of the skin, but especially on the head and in the cavity of the mouth. Although such end-buds are not found in the skin of air-breathing vertebrates, yet they persist in the mouth, where, from being organs of a more general tactile function, they are specialized as organs of taste. The second category embraces a very important group of sense organs, the nerve-hillocks or neuromasts, which are found in all fishes and aquatic amphibians; they differ in shape, as well as in the form of the sense-cells, from

the above, and are often segmentally disposed. They are either free on the surface, as in the blind fishes, or retracted more or less within sacs, as in the sturgeon and cat-fish, or finally withdrawn from the epidermis entirely, and lying within canals in the corium which course through the head and along the lateral line of the body. Such neuromastic canals are present in fishes, with few exceptions; they are generally strengthened by bone round the place where the neuro-epithelial patch is situated, and, in fact, important scales and bones are developed with such organs as their centre of formation. Fig. 6 represents the three chief types of neuromasts met with in fishes. No such structures occur in the higher Vertebrata, unless the auditory organ is to be conceived as a very highly specialized group of protected neuromasts. Apart from the similarity in the structures of the neuro-epithelium, other theoretical considerations favor this view. It has been indicated that the skin of air-breathing vertebrates differs in many respects from that of aquatic forms. Very early that layer of the epidermis which corresponds to the most superficial stratum in the aquatic forms is thrust off, and underneath it one or more layers of cells dry up, flatten, and undergo a chemical change, which process results in the differentiation of two strata of epidermal cells, the superficial horny and deep mucous strata. The flattened scale-like cells of the former are constantly being rubbed off (or exuviated in greater masses, as in the snake's slough) and replaced by the cells of the lower layer, which retain the power of dividing. It is obvious that the formation of this horny layer is in direct response to the change of medium in which the animal lives.

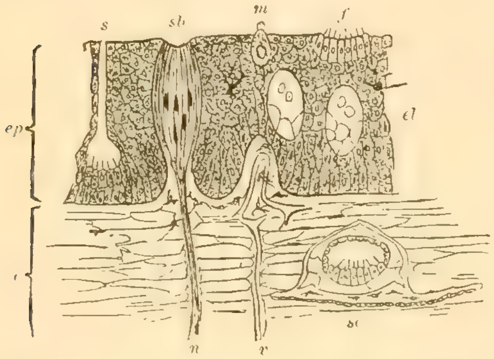


FIG. 6.—Diagrammatic section of the skin of a fish; *c*, corium; *cl*, clavate cells; *eb*, end-bud, or goblet organ; *f*, free neuromast; *m*, mucous cell; *n*, nerve; *p*, pigment cell; *s*, saccular neuromast; *sc*, mucous canal; *v*, vein; *ep*, epidermis.

Associated also therewith is the disappearance of the delicate neuro-epithelial structures discussed above. Although the nerves may still be traced into the cells of the mucous layer, yet specialized end-organs are now found only in the corium, where they occur in very various grades of evolution. In all, however, the sheath of the entering nerve-fibre is very much thickened, while the individual cells of the altered sheath are disposed either longitudinally or transversely in the club-shaped or globular 'tactile corpuscles.'

The lubrication of the surface effected by special cells in the lower forms is, in the Amphibia, brought about by the secretion of cutaneous glands. These are formed from the mucous layer of the epidermis, which may project inwards to some extent into the corium, and even receive a contractile sheath from it which regulates the discharge of the glandular secretion. They may occasionally take on special functions, as in the poison-glands of certain toads, etc. Such cutaneous glands are rare in the reptiles and birds, but they reappear in several distinct forms in mammals, where they associate themselves with very various functions.

Thus the sweat glands of mammals are important organs of excretion, assisting the kidneys in removing waste material from the body. Their deep position in the corium, although formed from the mucous layer of the epidermis, is characteristic.

Again, the sebaceous glands serve to lubricate the skin, and are closely connected with the hair follicles. Glands of this character are often largely developed in various groups of mammals, for the purpose of enabling individuals of a species to trace each other's whereabouts. Finally, the milk glands themselves of mammals are developed in the same way as the sebaceous glands, and, in the lowest division — the monotremes — their arrangement is such as to suggest that structures that at one time had a very different function have gradually been diverted towards that of supplying nutriment to the young.

Epidermal Appendages of the Skin.

With the change from an aquatic to a terrestrial life, which results, as above remarked, in the hardening of the exposed layer of epidermal cells with a horny layer, we find that certain additional protective or defensive structures are developed, composed of epidermal cells, which have undergone the same horny transformation, but which are often very specialized and characteristic of the different groups of the air-breathing vertebrates. These structures are always formed by the activity of the mucous layer of the epidermis, which generally retains the power of reproducing them when lost. Their presence always affects the underlying corium, and in many instances they may have important relations to underlying bones, whether these belong to the skin, as in the case of the horny tortoise-shell, which covers the bony carapax of the turtle; or to the internal skeleton, as is the case of the horns of oxen; or of the nails, claws, and hoofs of air-breathing vertebrates. But again, they may be confined to the skin, without entering into such relations, as is the case with most scales. Feathers and hairs, one of the structures referred to, belong to the category of epidermal appendages, as do also the horny pads or callosities met with in places liable to pressure, throughout all the groups of air-breathing vertebrates. In many cases the cellular structures of these is readily demonstrable, but in others (scales, hairs, horns) the elements are so altered as to give a fibrillated appearance to the tissue. Throughout the chapters which treat of the air-breathing vertebrates, many references will be found as to the extreme variety of form which these protective and defensive corneous structures may assume, here it is very necessary to call attention to the similarity in their mode of development. Even structures so different as hair and feathers have, in this respect, many points in common; only that phase of the development of the feathers in which the papilla of the corium pushes out the overlying epidermis beyond the free surface, is not found in the hair, where the first stage of development is an inward growth of the mucous layer of the epidermis, into which the papilla of the corium afterwards grows.

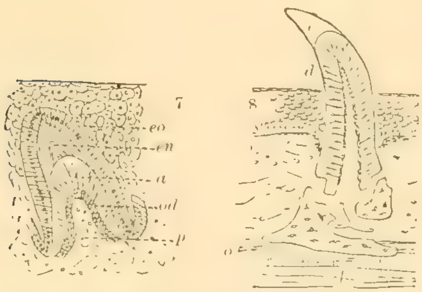
SKELETAL STRUCTURES.

Under this heading are embraced all the hard parts which serve for the support of the body, and likewise for the protection of internal organs. Frequently the skin is the seat of such skeletal structures; when this is the case the structures are termed collectively the exoskeleton; the term endoskeleton is being reserved for those structures which are developed in deeper layers of the mesoblast.

Exoskeleton.

Structures of this category are certainly more frequently found in the lower than the higher Vertebrata. The scales of fishes are all of this character, however sing-

ular the modifications which they assume. The most primitive exoskeletal structures are the little teeth which beset the skin in sharks, constituting the 'shagreen,' derived from them; similar teeth occur in the skin of the sturgeon between the larger bony plates, so characteristic of that fish. The mode of formation of such teeth may be readily understood from Figs. 7 and 8, which illustrates the development of such dermal teeth in one of the mailed siluroids. The seat of formation is obviously one of the papillæ of the corium, but certain connective tissue cells clothing the papilla (*od*) have the property of secreting a substance which becomes impregnated with salts of lime, and simultaneously of leaving some of their own processes in the hard substance so formed. This is dentine, and the forming cells are termed odontoblasts. The surface of the young tooth becomes coated with a cap of very hard enamel (*e*), which is secreted from the lower columnar layer of epidermal cells, modified at this place into a so-called enamel organ. Eventually the tooth grows out beyond the level of the epidermis, the papilla remains as the pulp cavity of the tooth, and all trace of the epidermal cells are soon rubbed off from the enamel cap. Deeper down in the corium a sort of socket is formed for the tooth by the formation from the connective tissue of a small plate of bone, so-called cement bone. These structures are of great interest and importance, because the bony plates of the sturgeon, already referred to, are simply formed by the fusion of such cement plates, and even the rhomboid scales of the gar-pike have a similar origin, although they have lost the asperities which characterize the plate of the sturgeon. The various forms of scales met with in the Teleosts are developed in the corium in a similar way, but in the ordinary 'cycloid' and 'ctenoid' scales, there is never any enamel or dentine formed on their surface. We have noted above that similar bony plates may be also formed for the protection of the sense organs lodged in the corium, and it is necessary to call attention specially to these two forms of dermal bones, as we shall find them later entering into such important relationships with the endoskeleton, that we shall have to treat of them in that connection. Few exoskeletal structures occur in the Amphibia. Crocodiles, on the other hand, are well provided with such plates, but they nowhere reach such a high degree of development as in the turtles, where they form a more or less complete box for the protection of the animal. Many of the plates developed in the corium in this way enter into close union with parts of the endoskeleton, others are quite free from such connection, while all are closely enveloped by the horny scales of epidermal origin; in many a thin strip of unossified corium and the mucous layer of the epidermis intervening between them (Fig. 9). Few mammals are possessed of dermal bones of similar origin to those of the turtles, but the living and extinct armadillos of South America form an exception to this rule.



FIGS. 7 and 8.— Embryonic and mature teeth in skin of a mailed siluroid; *c*, cement bone developed as a socket for the tooth; *d*, dentine; *e*, enamel; *eo*, enamel organ; *od*, odontoblast; *p*, papilla.

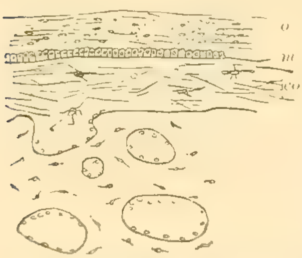


FIG. 9.— Section through the carapax of a turtle; *co*, corium; *e*, epidermis; *m*, mucous layer.

THE ENDOSKELETON.

The mode of origin of the notochord has been discussed above; its relationship to the skeleton of the adult, as well as to the other organs of the body, must now be described. It is only in lower forms, like Amphioxus and the Myzonts, that the notochord persists in its whole length in the adult. Usually it is profoundly altered by the formation of surrounding hard parts. On their first appearance in the embryo of higher, as well as in the adults of lower, forms, these are simply represented by a continuous unsegmented investing sheath of connective tissue, which has the potentiality of developing into skeletal structures (the skeletogenous sheath); but very soon the segmental character becomes impressed upon this, and is, no doubt, traceable to the influence of the strains of the muscles on the sides of the sheath in locomotion. That the segmentation of the sheath and the muscles have a very intimate relation to each other may be seen from Fig. 10, which represents a horizontal slice through the notochord of a young gar-pike. The cartilaginous sheath, although continuous round the notochord, exhibits a distinct segmentation; it pushes out on either side certain processes (*ha*), the hæmal arches, which run out between the muscle-segments, and are in the adult continued by the ribs, although at this stage these are not yet to be found in the membranous partitions (the myocommata) which are attached to the ends of the hæmal arches, and separate the muscle-segments. Opposite the hæmal arches the notochord is distinctly constricted, and this point corresponds to the middle of the vertebra of the adult, while in the place corresponding to the interval between two contiguous vertebræ the notochord is considerably thicker. Figs. 11 and 12 serve to illustrate more fully the relation of the central skeleton to the notochord; both represent frontal sections through a young gar-pike, a little behind the head; but 12 is through a vertebra, while 11 is through an intervertebral space. Above the notochord is the spinal cord, giving origin to a pair of spinal nerves, and separated from the surrounding muscles by an arch which, except a triangular block of

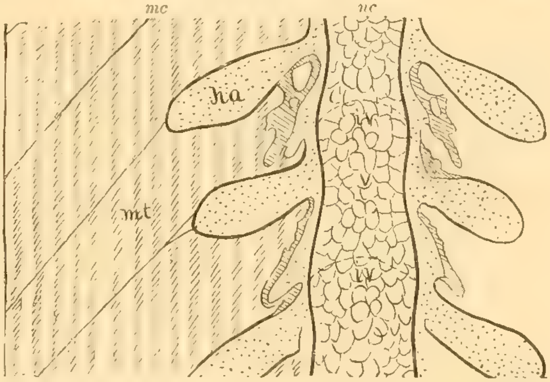


FIG. 10.— Horizontal section of a young gar-pike on the level with the notochord (*nc*; *mt*, myotomes, separated by septa or myocommata (*mc*) attached to the ends of the hæmal arches (*ha*); *v*, corresponds to the centre of a vertebra, the anterior and posterior faces of which are indicated by a dotted outline. The notochord still is wider intervertebrally, *iv*.

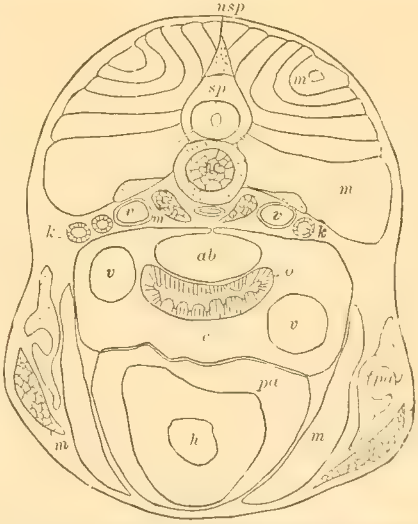


FIG. 11.— Frontal section through intervertebral space of young gar-pike in the region of the pectoral fins; *nsp*, neural spine; *sp*, spinal cord; *m*, muscles; *v*, veins; *k*, kidney; *ao*, aorta; *ab*, air bladder; *o*, œsophagus; *c*, cœlom; *pc*, pericardial cavity; *ht*, heart; *pa*, pectoral arch.

cartilage forming its key, is merely membranous. Below the notochord is the principal artery, the aorta, with the trunk veins and the kidneys on either side. These lie above and outside the cœlom, a space which contains the viscera (in this region chiefly the air bladder and the œsophagus), and a part of which is partitioned off as the pericardial cavity to accommodate the heart. The lateral walls of the cœlom are formed by muscles which attach themselves to the supporting cartilage of the fore fin, the 'pectoral arch.' Fig. 12 shows how the chief parts of the permanent vertebra arise.

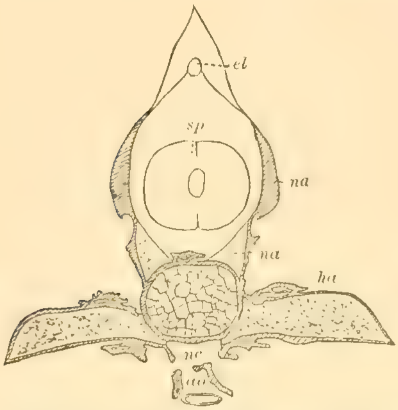


FIG. 12.—Section through vertebra of young gar-pike; *ha*, cartilaginous hæmal and (*na*) neural arches; the surrounding perichondrium is giving rise to bone continuous with the osseous neural arch (*na*) developed in the membranous wall of the spinal canal (*sp*); *el*, elastic ligament; *nc*, notochord.

Two cartilaginous hæmal arches (called so on account of their relationship to the chief blood vessel) jut outwards and backwards, and two neural arches of the same tissue project upwards so as partly to wall in the spinal cord. But bone is beginning to appear chiefly in the membrane surrounding the cartilage (perichondrium) and is extending also in the rest of the membranous wall round the spinal cord. In this way are formed the essential elements of a vertebra, viz. a central part surrounding the notochord, the body or centrum; two lateral parts, the neural arches, which serve to protect the spinal cord, and are aided in this by a dorsal neural spine; and, finally, two hæmal arches continuous with the ribs, which, in their turn, help to strengthen the wall of the cœlom, and may, in higher forms, unite in a breast-bone or sternum on the ventral surface of that cavity. Further elements of the vertebræ are present in higher forms, serving for the purpose of securing union between the arches of contiguous vertebræ (articular processes), or as additional points of support for the ribs (transverse processes), or for the attachment of muscles. The edges of the centra likewise occasionally develop articular processes, but as a rule the connection between contiguous centra (except where they are fused together) is effected by ligaments.

The extent to which the notochord persists varies greatly in different groups. Teleosts present little advance upon the stage of the gar-pike described above, the individual vertebræ being deeply hollowed on either face (amphicœlous), and retaining in the hollows a very considerable amount of notochord, while in the gar-pike itself a ball-and-socket joint forms between contiguous vertebræ, the sockets occupying the hinder faces (opisthocœlous vertebræ). Little or none of the notochord is left in the interior of each vertebra, and this is likewise frequently the case in reptiles, where the socket often occupies the anterior face of the vertebra, which is then styled procœlous. In most Mammalia a special provision is made for the slow attainment of the adult length of the vertebral column, in that the faces of the vertebræ are furnished with 'epiphyses,' separate plates of bone, between which and the centra proper a zone of cartilage allows for additions to the length, until, when the adult size is attained, the epiphyses fuse with the centra and then form their faces. In the mammals also well-formed intervertebral discs of fibro-cartilage unite the faces of contiguous vertebræ, and contain some trace of the notochord, even in the adult condition.

An important difference between the vertebral column of higher and lower forms

is observable in the greater distinctness of the regions into which the column is divisible in the higher forms. In a fish one distinguishes between trunk-vertebræ and tail-vertebræ, the latter being in that part of the body behind the cœlom, while in most higher forms (Fig. 13) five regions are distinguishable. Thus cervical vertebræ are distinguished from the succeeding trunk vertebræ by the fact that their ribs (when present) do not unite ventrally in a sternum. Again, certain sacral vertebræ are specialized by their ribs affording support to the pelvic girdle, which, in its turn, supports the hind limbs. Behind the sacral region is the caudal region; in front of it, the trunk, or dorso-lumbar region, composed of the dorsal and lumbar vertebræ, the latter differing from the former in having no movable ribs.

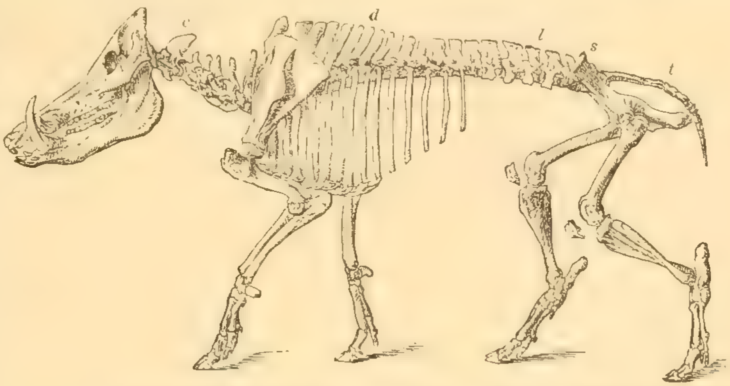


FIG. 13.—Skeleton of boar; *c*, cervical; *d*, dorsal; *l*, lumbar; *s*, sacral, and *t*, caudal vertebræ.

Throughout the vertebrates we meet with parts of the vertebral column, modified in connection with requirements of the most various character. The union with the head modifies the first (atlas) or first two vertebræ (atlas and axis). In some Teleosts certain anterior vertebræ are altered in form to establish communication between the air-bladder and the ear; and in all, the end of the caudal region is modified in connection with the caudal fin. Again, fusion of certain tracts is normal in the sacrum, and may be exceptionally present in other regions, as the tip of the tail in birds, the dorsal region in turtles, etc.

THE RIBS AND STERNUM.

The mode in which the ribs of the gar-pike are developed, continuously with the hæmal arches, has been referred to above. Whether the ribs of the higher forms, which frequently unite in the ventral middle line to form a sternum, are homologous structures, is not yet completely determined. That the second point of contact obtained with the neural arch of the vertebra is a new acquisition of the higher forms has been hinted at above. In defining the regions of the vertebral column of the higher forms, it has been indicated that in these the ribs are very different in different regions. Cervical ribs may be movable, but they are generally so short and so fused with the vertebra, that they merely form a 'perforated' transverse process. Dorsal ribs, on the other hand, as already mentioned, unite to form the sternum; this they do by their ventral ends fusing together into two cartilaginous

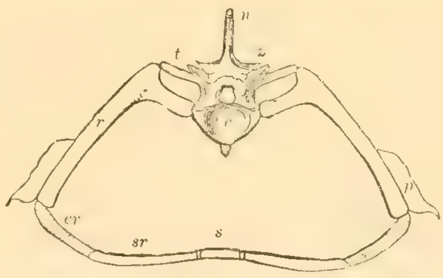


FIG. 14.—Section of the thoracic region of the skeleton of a crocodile; *c*, centrum of vertebra; *cr*, cartilaginous portion of vertebral rib; *n*, neural spine; *p*, uncinate process on *r*, vertebral rib; *s*, sternum; *sr*, sternal rib; *t*, transverse process; *z*, articular process.

strips or plates, which eventually unite with each other. Fig. 14, which represents a section of the thoracic region of a crocodile, shows the intimate relation that these structures have to each other, to which reference will afterwards be made. The sternal and vertebral halves of the ribs (*r* and *sr*) may be somewhat independent of each other, and the latter may be locked together by overlapping uncinate processes. After the fusion of the cartilaginous strips into the sternum, the latter frequently becomes in the mammals secondarily segmented into bones to the intervals between which the ribs are attached, (Fig. 15).

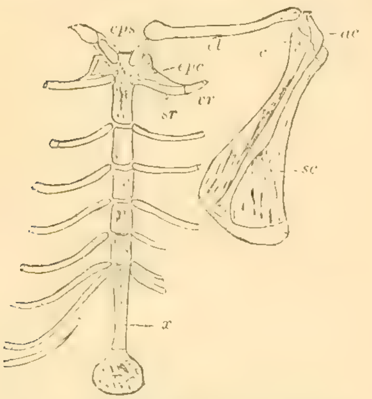


FIG. 15.—Shoulder-girdle of a field mouse ; *ac*, acromion process ; *c*, coracoid process ; *cl*, clavicle ; *eps*, episternum ; *sc*, scapula ; *sr*, sternal; *r*, vertebral rib ; *x*, xiphoid cartilage.

The snakes are characterized by the absence of a sternum, which, like the absence of the limbs, is presumably secondary. A similar explanation must be given for the absence of the sternal ends of the ribs in Amphibia, where the sternum itself is present and closely connected with the shoulder-girdle.

THE SKULL.

Just as the vertebral column is derived from the skeletogenous tissue surrounding the notochord, so the groundwork of the skull is derived from similar tissue, which lies on either side and in front of the cephalic end of the notochord. But the demands on this tissue are of a very different character in the cephalic end of the body. The central nervous system in this region swells out into the brain ; for this a special protective capsule is required, which, of course, adapts itself in form to its contents. No segmentation like that in the vertebral column occurs in this chondrocranium, which is further modified by protecting the auditory organ behind, the olfactory in front, and, to a less extent, the eye in the middle. These organs thus mark out regions in the chondrocranium (the olfactory, orbital, and auditory) while a fourth region, the occipital, is that which establishes the union with the vertebral column.

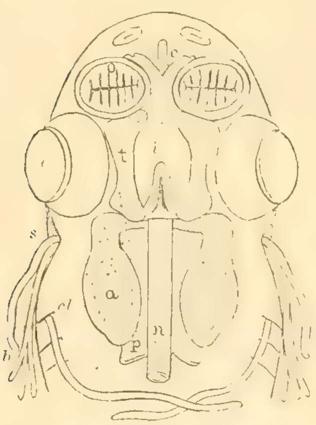


FIG. 16.—Head of embryo dog-fish : *a*, auditory capsule ; *c*, trabecular cornua ; *cl*, visceral clefts ; *b*, branchiæ; *e*, eye ; *i*, infundibulum ; *o*, olfactory organ ; *n*, notochord ; *p*, parachordal cartilage ; *s*, spiracle ; *t*, trabecula.

Fig. 16 indicates how part of the skeletogenous tissue (*p*, the parachordal tracts) lies at the side of the notochord, while two other tracts (the trabeculæ) are entirely prechordal, and thus not comparable to the tissue around the notochord. The parachordal tracts soon coalesce with the auditory capsules, and tend to grow upwards round the brain, as do the trabecular tracts further forwards. The latter also contribute to the formation of the olfactory capsules, so that a cartilaginous box for the accommodation of the brain results, the walls of which are, however, in most forms, deficient in certain places (fontanelles). It is this chondrocranium which furnishes the substratum in or on which the cranial bones are developed. Even in its notochor-

dal region no evidences can be detected of a division into vertebral segments, unless, indeed, certain arches which are attached to its ventral face are to be so regarded.

To understand the nature of these, it is necessary to anticipate here the description of a feature of the alimentary canal, which is common to all vertebrates. In the aquatic vertebrates the anterior part of the alimentary canal communicates with the outside by a series of gill-clefts on either side, through which the water streams for respiratory purposes. Although these gill-clefts entirely disappear, with the exception of the first, in the adults of air-breathing vertebrates, yet they are present in the embryos of all, even the highest. Between the clefts (also known as visceral clefts) are left certain solid pillars, the visceral folds, and these are strengthened by cartilaginous supports, the visceral arches, which are only developed to a small extent in the adults of air-breathing forms, but attain the maximum of their development in aquatic species, as the gill or branchial skeleton (Fig. 17.) Many anatomists consider these arches to be homodynamous with the hæmal arches and ribs further back, and thus to represent the hæmal arches of the notochordal part of the skull, but this must still be considered as not sufficiently made out; for the side walls of the head, in which they make their appearance, do not participate in the segmentation, which we shall afterwards see is observable in certain organs of the upper part of the head, although not in the chondrocranium.

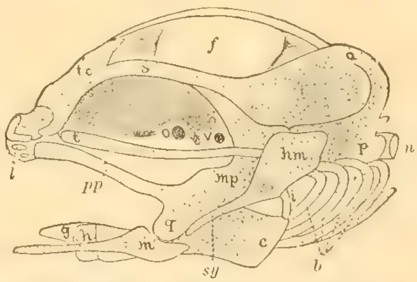


FIG. 17.—Skull of young salmon, membrane bones removed; *a*, auditory capsule; *b*, branchial arches; *c*, ceratohyal; *f*, superior fontanelle; *g*, glossohyal; *h*, hypohyal; *hm*, hyomandibular cartilage; *i*, interhyal; *l*, labial cartilages; *m*, Meckelian cartilage; *n*, notochord; *o*, optic foramen; *p*, parachordal cartilage; *pp*, palatopterygoid; *q*, quadrate; *s*, supra orbital ridge; *sy*, symplectic; *t*, trabecular; *tc*, tegmen cranii; *v*, trigeminal foramen.

The greater part of this visceral or branchial skeleton may be conveniently discussed apart from the skull, but the whole of the first arch, and the upper part of the second arch, become so intimately related to the skull that it is necessary to take them into consideration along with it. Indeed, an actual fusion generally takes place between the upper (palato-quadrate) part of the first arch, which forms the upper jaw, and the chondrocranium, while the lower, or Meckelian, part (the lower jaw) is hinged upon the upper part (Fig. 17.) That we have also to take into consideration the upper part of the second arch (hyomandibulo-symplectic tract, *hm*, *sy*) is due to the fact that it loses to a great extent its union with the lower part, and takes on in many forms the function of the suspension of the lower jaw, being on this account styled the 'suspensorium.' But in higher forms this same tract loses that function and becomes subservient to the organ of hearing in a way to be afterwards described.

The stage of development of the salmon's skull represented in Fig. 17 affords a good idea of the cartilaginous substratum in and on which the future osseous structure is erected. To understand how this is effected, it is necessary to recall some points which have been referred to above, as to the development of bones in the skin. The sturgeon's skull is completely cartilaginous, but is covered on the outside by a series of bony plates formed in the skin, chiefly by the fusion of the cement plates of originally separate teeth; these are cement bones, and they afterwards play a very important part in filling up gaps or fontanelles in the chondrocranium, and in strengthening it from the outside. Cement bones are not confined to the free surface

of the head; they likewise occur in the cavity of the mouth, where the teeth more usually persist than on the free surface of the head. It is to be noted that, just as in the case of the scales of many fishes, the cement plates may remain, although the teeth (their *raison d'être*) have disappeared, so that cement bones are found on the skull and in the cavity of the mouth, without a trace of teeth.

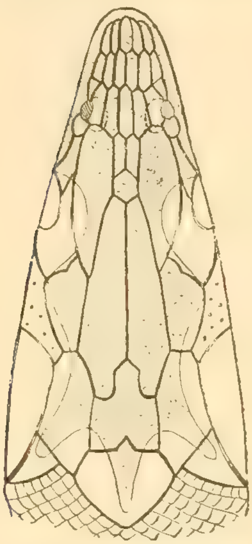


FIG. 18. — Head of sturgeon, showing the membrane bones covering the (dotted) chondrocranium.

Such cement bones are also spoken of as dermal bones, or investing bones, from their relation to the skin, or to the underlying skull respectively; but it is also usual to speak of another category of bones as dermal, which have an entirely different origin from the above, and which, indeed, are developed for the protection of the neuromastic canals referred to before. Such neuromastic bones are not confined to the aquatic vertebrates, but retain their relationship to the skull in air-breathing forms, although their original function has disappeared.

The cement bones and neuromastic bones are something superadded to the cartilaginous skull, and we shall find that they are not confined to the skull proper, but extend to those modified visceral arches which, roughly speaking, give rise to the jaws. But certain bones originate in closer relationship to the cartilage; they may first appear in the centre of certain cartilaginous tracts, and gradually replace the cartilage centrifugally, or they may appear in the membrane which clothes the cartilage (the perichondrium), and, eating into it, as it were, replace it centripetally. These are generally spoken of as 'cartilage bones,' as distinguished from the 'membrane' bones of the foregoing paragraph; but it is impossible to draw a very sharp distinction between them, for a bone which originates round a neuromastic canal, for example, may eat likewise centripetally into the underlying cartilage.

Again it may be impossible, except in the cavity of the mouth, to distinguish between the limits of neuromastic and cement bones; for two bones originating in these two different manners may fuse. It will therefore be sufficient to indicate the chief places where the chondrocranium and the cartilages of the jaws are replaced by the 'cartilage' bones, and where they are invested on the outside by 'membrane' bones.

It has been remarked above that a demarcation of the skull into regions is effected by the sense organs, but these regions are not 'segments.' So also the points of escape of the cranial nerves give valuable landmarks in the study of the skull, but neither do these mark off segments; for although many of them, as we shall see, are comparable to spinal nerves, yet they have lost the primitive segmental arrangement which the spinal nerves have retained.

In discussing the bony framework of the skull, it will be convenient to take the brain-box first, and the jaws afterwards. The occipital region generally exhibits four bones surrounding the foramen magnum or aperture through which the brain communicates with the spinal cord. These are the basioccipital below, the supraoccipital above, and the two exoccipitals, one at either side (Fig. 19), but the latter may alone appear in this region, as in the frog, the rest of the region remaining cartilaginous. The bones of the auditory region are more numerous; their limits are generally detectable

in lower forms, but in the adults of higher forms they fuse on each side into one mass, the petrosal bone, as do the four occipital elements into the occipital bone. The three most commonly occurring elements are the prootic in the fore-part of the ear-capsule, the epiotic above, and the opisthotic behind, but certain additional elements are found forming part of the wall of the ear-capsule as well as the socket for the suspensorium in Teleosts, the sphenotic (post frontal) and pterotic. These bones may be partly dermal in their origin; the latter being intimately connected with a dermal bone, the squamosal.

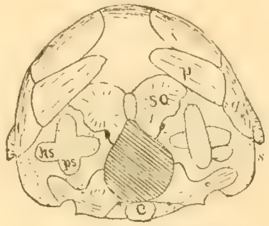


FIG. 19.—Base of cranium of an embryo chick; *c*, condyle; *eo*, exoccipital; *f*, frontal; *hs*, horizontal, and *ps*, posterior semicircular canals; *p*, parietal; *s*, sphenotic process; *so*, supraoccipital; *sq*, squamosal.

In the cartilage of the base of the skull, between and in front of the auditory capsules, one or two bones appear, continuing forward the basioccipital; these are called the basi- and pre-sphenoids. In the same relation to these that the exoccipitals have to the basioccipital are the ali- and orbito-sphenoids, which form part of the lateral wall of the cranium in the orbital region. But there is no ossification in the roof of the chondrocranium, here comparable to the supraoccipital, and, indeed, in many forms the basal elements persist only as cartilage.

In many forms, as birds, the cranial cavity is very much compressed from side to side in the orbital region. The result is a mere thin partition between the orbits — the interorbital septum — in which the sphenoidal elements are to be sought. But the olfactory region is either entirely in front of the cranial cavity, or two tubular prolongations of the latter convey forwards the olfactory tracts to the neuro-epithelium to which they are destined. A nasal septum, derived from the coalesced trabeculæ, separates the olfactory organs of the two sides, and is continuous with lateral plates protecting the organs. If ossifications appear in these septal and lateral cartilages, they are termed mesethmoid, and lateral ethmoids. When the surface on which the nasal mucous membrane is distributed becomes very complex, as it does in mammals, special ingrowths of the olfactory capsule ossify as turbinal bones.

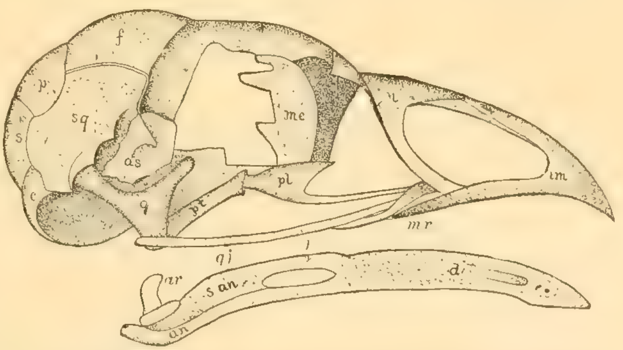


FIG. 20.—Skull of young sage-cock (*Centrocercus*); *an*, angular; *ar*, articular; *as*, alisphenoid; *d*, dentary; *e*, exoccipital; *f*, frontal; *im*, premaxillary; *j*, jugal; *me*, mesethmoid; *mx*, maxillary; *n*, nasal; *p*, parietal; *pl*, palatine; *pt*, pterygoid; *q*, quadrate; *qj*, quadrato-jugal; *s*, supraoccipital; *san*, surangular; *sq*, squamosal.

Related to the roof of the chondrocranium are membrane bones which, when the cartilaginous box becomes insufficient in size to accommodate the brain, fill up the gaps, and become thus directly related to the brain. These are known as parietals, squamosals, frontals, prefrontals, and nasals (Fig. 20). Similarly related to the ventral face of the chondrocranium are the vomer in front, and parasphenoid behind, retaining in many instances the teeth to which they owe their origin. All of these membrane bones persist in the higher classes of vertebrates, some of them, such as the parasphenoid, losing, while others, like the frontals and parietals, gain in importance. But we may observe in the Teleosts many membrane bones

which disappear with the loss of the system of neuromastic canals. Such are, *e. g.*, the bones which surround the eye in most forms, and serve to protect the infraorbital branch of the neuromastic canal system.

It is now time to devote some attention to the cartilages of the jaws and their products. The first arch early shows a division into two parts, the upper palato-quadrate, the lower mandibular. Between the two, the quadrato-mandibular articulation is formed. The cartilages immediately entering into this joint are usually ossified as quadrate above and articular below, but the fate of the remainder of the cartilages is very different in different groups. As many as five different ossifications in addition to the articular may unite to form what we call the mandible or lower jaw. Some of these may be cartilage bones, some membrane, and the greater part of the cartilage may persist in some lower forms as the 'Meckelian' cartilage surrounded by these membrane bones. Of these the chief is certainly the dentary, the origin of which from teeth is at once apparent, while others again, such as the coronoid and angular, are developed in response to muscular strains. It is only in the fishes that the upper part of this arch is so independent of the skull (Fig. 21). Generally the elements developed from it are connected with the proper cranial bones so intimately that they contribute largely to the formation of the floor and side walls of the skull. In addition to the quadrate, certain cartilage elements known as pterygoids and palatines appear in this arch, and other membrane bones, chiefly of the category of cement bones, are developed upon it. The latter are known as premaxillary, maxillary, jugal, and quadratojugal. But the distinction between membrane and cartilage bones is here again difficult to maintain, for a palatine may be in part of cartilaginous origin and in part a cement bone. The arrangement of the bones developed from the palato-quadrate arch is highly characteristic of the different groups of vertebrates. Frequently two distinct rows of bones are formed leading from the maxillary to the quadrate (Fig. 20), the outer row including the jugal and quadrato-jugal, while the inner row is formed of the palatine and pterygoid. Again, a transpalatine may connect the two rows in many reptiles. The reason of the greater development of the palatine and pterygoid bones, in many higher forms, such as turtles and crocodiles, is to be sought for in the separation of a nasal cavity from the primitive mouth cavity. Such a compartment of the mouth cavity does not exist in fishes; its formation is brought about by the development of a partition, the palate, which shuts off a greater or less portion of the mouth cavity as the nasal cavity. This partition may in part be destitute of an osseous framework. It is then called the soft palate; while the hard palate is formed by shelves developed from the premaxillary and maxillary bones, with the assistance of the palatines and pterygoids. The latter in mammals rarely contribute much to the formation of the hard palate, being generally attached to the sphenoid bone as pterygoid processes.

It is obvious from the above sketch, that many of the peculiarities of the skulls in the various groups of vertebrates are traceable to the differing modifications of the palato-quadrate arch. This is true of the relationship of the quadrate to the neighboring bones. Sometimes it is very independent of the rest of the skull, as in snakes and birds (Fig. 22); sometimes it is wedged firmly in with the neighboring bones, as in turtles and crocodiles.

In all Amphibia, Reptilia, and Aves, the suspension of the lower jaw is not effected, as in fishes, by the aid of the following arch, but the quadrate alone articulates with the mandible. We shall consider presently the nature of the articulation of the lower jaw in mammals.

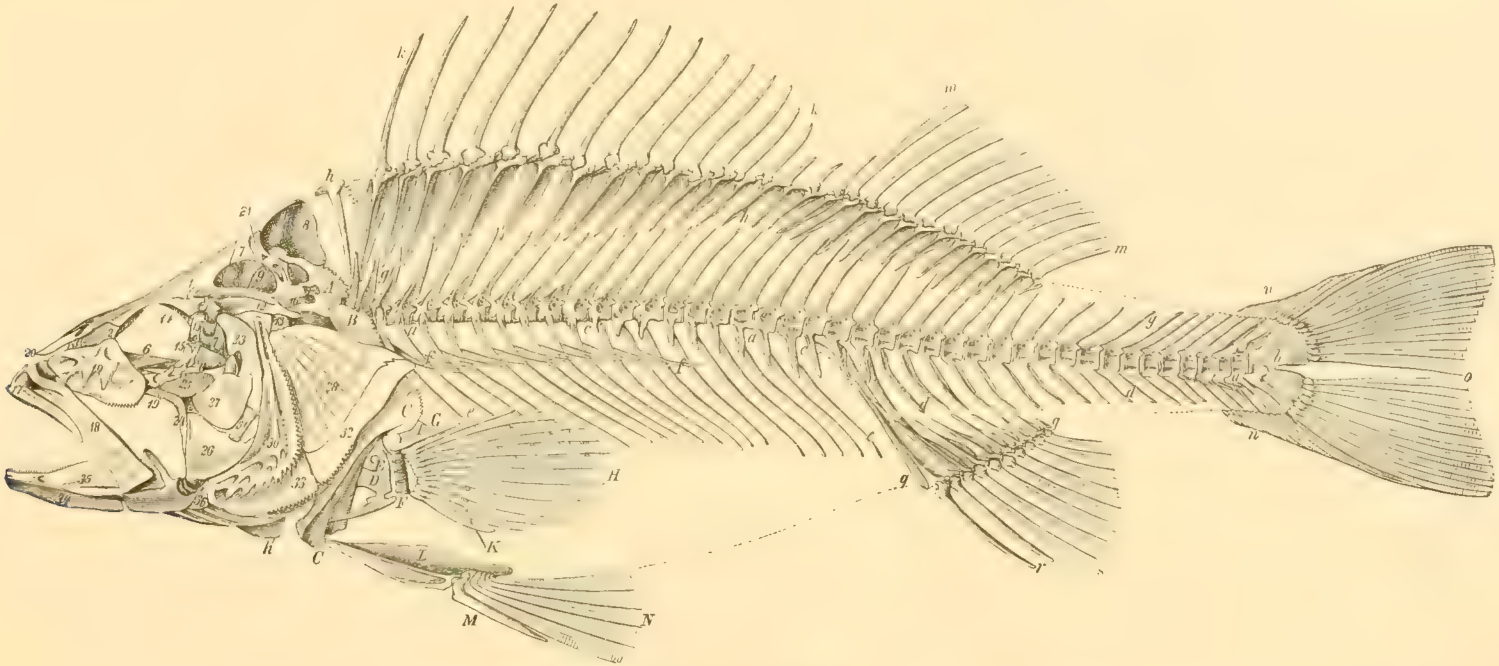


FIG. 21. — Skeleton of a perch.

1, frontal.
2, prefrontal.
3, ethmoid.
4, post-frontal.
6, parasphenoid.
7, prootic.
8, supraoccipital.
9, opisthotic.
10, exoccipital.
11, parietal.
12, pterotic.
13, squamosal.
14, alisphenoid.
15. infraorbitals.
17, premaxillary.
18, maxillary.
19, suborbitals.
20, nasal.
21, epiotic.
23, hyomandibular.
24, pterygoid.
25, mesopterygoid.
26, quadrate.
27, metapterygoid.
28, operculum.
30, preoperculum.
31, symplectic.
32, suboperculum.
33, interoperculum
34, dentary.
35, articular.
36, angular.
A, post-temporal.
B, supraclavicula.
C, clavicula.
D, coracoid.
E, scapula.
F, basalia.
G, pectoral spine.
H, pectoral fin rays.
I, *K*, post-clavicula.
L, pubic.
M, ventral spine.
N, ventral fin-rays.
a, vertebræ.
b, hypural bone.
c, transverse or hæmal processes.
d, hæmal processes of caudal region united to form an arch for the aorta.
e, ribs.
f, epipleural spines.
g, neural spines.
h, interneural spines.
k, dorsal spines.
m, fin-rays of second dorsal.
n, rudimentary caudal rays.
o, caudal rays.
q, interhæmal spines.
r, anal spines.
s, anal fin-rays.

It has been mentioned above that the upper part of the second or hyoid arch possesses the function in many fishes of supporting partly or entirely the mandible. Such skulls have been called hyostylic, in contradistinction to those autostylic skulls, where the quadrate alone performs this duty. The hyoid suspensorium, when present as such, may be a single stout bar, as in the sharks, or may be divided into two pieces, an upper hyomandibular and lower symplectic, which ossify separately. Connected with the interval between these is the lower part of the hyoid arch, by a bony or cartilaginous bar, the interhyal (Fig. 17). In those fishes where a gill-cover is developed (Ganoids and Teleosts) the skeleton of the gill-cover is very intimately related to the hyomandibular. Generally four bones are present in it, the preopercular, opercular, subopercular, and the interopercular; the first of these is developed round a neuromastic canal, while the others appear to be similar to the branchiostegal rays which support the membranous fold developed from the lower part of the hyoid arch, and assisting in the protection of the gills (Fig. 21).

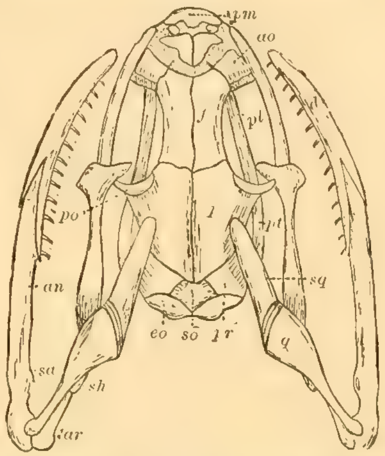


Fig. 22.—Skull of snake (*Tropidonotus*); *an*, angular; *ao*, antorbital; *ar*, articular; *d*, dentary; *eo*, exoccipital; *f*, frontal; *p*, parietal; *pl*, palatine; *pm*, premaxillary; *pr*, prootic; *pt*, pterygoid; *q*, quadrate; *sa*, surangular; *sh*, stylohyoid; *so*, supraoccipital; *sq*, squamosal.

The gill-cover is absent in the Amphibia and higher classes, and the mandible is suspended by the quadrate, but we have still to look for the homologue of the hyoid suspensorium, which is now to be found as a chain of bones more or less numerous, now subservient to hearing, and effecting communication between the membrane of the drum of the ear and the internal ear. This chain is the columella auris, which exhibits much difference in its form in the amphibians, reptiles, and birds. Some doubt is entertained by morphologists as to the homology of the chain of bones which perform the same function in mammals, and this doubt extends to the nature of the articulation of the lower jaw in that group. Unlike the lower classes, where the mandible is articulated with an independent quadrate, the mammals have the socket for the lower jaw on a bone of very complex nature, the 'temporal' bone. This bone not only contains all the bones of the auditory capsule, but also a tympanic developed in connection with the drum of the ear; the squamosal, which is separate in the lower forms, and a 'zygomatic' process of that part the root of which bears the glenoid socket for the mandible (Fig. 23). It has recently been asserted that the malar bone of mammals is likewise of complex nature, representing the postfrontal, jugal, and quadrato-jugal of reptiles; further that the zygomatic process of the squamosal with which it articulates is nothing else than the quadrate of the lower classes; if so, the articulation of the lower jaw is the same in mammals as in lower forms, and this view derives support, according to Professor Cope, from the condition of affairs in the theromorphous reptiles. On the other hand it has generally been believed that the quadrate is represented in mammals by the malleus, one of the chain of bones in the

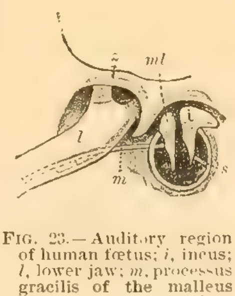


Fig. 23.—Auditory region of human fœtus; *i*, incus; *l*, lower jaw; *m*, processus gracilis of the malleus joining the Meckelian cartilage of the lower jaw; *ml*, malleus; *s*, stapes, within the tympanic ring; *z*, zygomatic arch of temporal bone, bearing the glenoid fossa.

drum of the ear, and that the other bones in the chain, the incus, orbiculare, and stapes, represent the columella auris of the reptiles. Although this is still a moot point in morphology, the former account is certainly that which offers fewest difficulties to the evolutionist. Such complex bones as are referred to above are no exception in the higher vertebrates. The tendency to the fusion of originally separate elements is very marked in birds, where, indeed, all the walls of the cranial cavity early form a continuous mass in which it is impossible to detect the separate elements. Only the bones of the face retain a certain amount of independence. Again in mammals we frequently find all of the sphenoidal elements united into a sphenoid bone, just as the separate occipital elements, together with the interparietal, form the complex occipital bone.

The greatest contrast is to be observed within the different groups, as to the relative size of that part of the skull which comes into relation to the brain (the cranium), and the part which lies in front of it — the face. This is perhaps as well seen in the Mammalia as elsewhere, owing chiefly to the enormous development of the turbinal surfaces clothed by the nasal mucous membrane, and the consequent large size of the olfactory region of the skull.

In the above account of the vertebrate skull, the object has been to indicate the nature and arrangement of its component elements. The peculiarities of each group will be discussed under the special description of each.

The Visceral Skeleton.

This term is applied to the series of arches which intervene between the gill-clefts. The first cleft is styled hyomandibular, because it lies between the hyoid arch behind, and the palato-mandibular arch in front. The second cleft is the first branchial, and it separates the hyoid arch from the first branchial arch. We have already considered the whole of the first arch and the upper part of the second; there remain for treatment the lower part of the second and the various branchial arches proper. It will be observed that visceral arch is a term applicable to all of these structures, while branchial arch is confined to the third and succeeding visceral arches, even although in some fishes both mandibular and hyoid arch, in spite of their specialization, have not entirely lost their gill-bearing function.

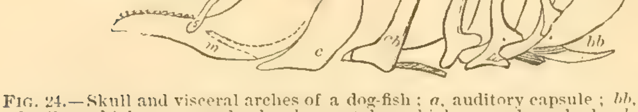


FIG. 24.—Skull and visceral arches of a dog-fish; *a*, auditory capsule; *bb*, basibranchial; *c*, ceratohyal; *cb*, ceratobranchial; *e*, epibranchial; *eb*, extrabranchial; *hm*, hyomandibular; *m*, lower jaw; *mp*, metapterygoid ligament; *n*, nasal capsule; *q*, pterygo-quadrate arcade; *pb*, pharyngobranchial; *pn*, prenasal cartilage; *s*, supraorbital ridge; *sp*, spiracle; *t*, palato-trabecular ligament; *v*, trigeminal foramen; 1, 2, 3, 4, 5, labial cartilages.

It is to the aquatic vertebrates that we must look for the full development of these structures. With the loss of gills in air-breathing forms, all of the branchial arches disappear except the first, and this generally is much reduced in size.

The lower portion of the hyoid arch is generally more subdivided in fishes than the corresponding segments of the succeeding arches, but a fundamental similarity is nevertheless observable. Thus certain basal elements or copulæ unite the ventral

ends of the visceral arches; the first of these is the basihyal, while the succeeding are styled basibranchials. In most forms the basihyal attains greater importance from its supporting the tongue, into which it sends forwards an entoglossal or glossohyal process. It is to this relationship to the tongue, that the hyoid arch owes its name, and its persistence throughout the higher forms. The lower part of the arch retains its connection with the upper part, in fishes, by means of an interhyal piece, between which and the basihyal are generally found epiceratohyal, ceratohyal, and hypohyal pieces (Fig. 25). In the higher forms, where the upper part of the arch has become subservient to the auditory organ, the lower part is attached to the auditory region of the skull by a tympanohyal, between which and the basihyal the following ossifications may occur: stylohyal, epihyal, ceratohyal; but some or all of these may remain unossified. When present they are known as the anterior cornua of the hyoid bone (Fig. 26). The posterior cornua of the hyoid are the remains of the first branchial arches, and may enter into important relations with the larynx.

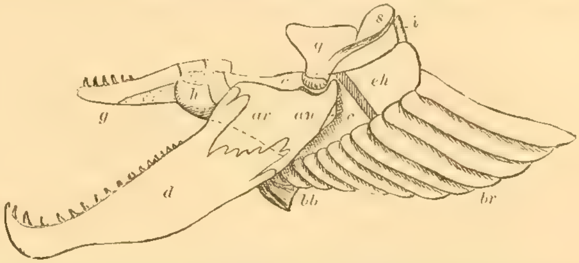


FIG. 25. — Lower jaw and hyoid arch of salmon; *an*, angular; *ar*, articular; *bb*, basibranchiostegal; *br*, branchiostegal rays; *c*, ceratohyal; *d*, dentary; *e*, epiceratohyal; *g*, glossohyal; *h*, hypohyal; *i*, interhyal; *q*, quadrate; *s*, symplectic.

The basibranchials are rarely independently represented, except in fishes, where, however, they are frequently coalesced. In the arches themselves, the following separate pieces are generally present (Fig. 24): hypobranchials, ceratobranchial, epibranchials and pharyngobranchials, the latter being loosely attached to the ventral face of the skull, and generally carrying superior pharyngeal cement bones on them, which are covered with teeth. In most bony fishes the fifth arch supports no gill, but bears on the surface, turned towards the mouth, considerable dentigerous cement plates — the inferior pharyngeal bones.

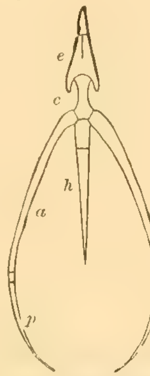


FIG. 26. — Hyoid apparatus of common fowl; *a*, ceratobranchial; *c*, first basibranchial; *e*, ceratohyal; *h*, second basibranchial; *p*, epibranchial.

THE SKELETON OF THE LIMBS.

Two systems of locomotor appendages are distinguished in the vertebrates — a median unpaired system confined to the fishes and aquatic amphibians, and the two paired anterior and posterior appendages, typical of the whole branch. In certain primitive forms the median unpaired fin may be an almost continuous fold occupying the dorsal and ventral middle line, but the tendency is towards its restriction to certain tracts which will be treated of in detail in the special description of the fishes. In this class alone is the fold supported by fin-rays; these in their turn rest on bones, which are either wedged in between the spines of the vertebral column (hence interspinous bones), or are continuous with these and thus answer to the segmentation of the body. They may be present although the corresponding tract of unpaired fin has disappeared.

According to the most prevalent theory the paired fins have become developed by

similar restriction of primitively continuous right and left lateral folds to two tracts, an anterior and posterior on either side. These tracts, which are in their most primitive condition in certain sharks, have given rise to the paired fins of other fishes, and to the anterior and posterior extremities of the higher vertebrates. Like the unpaired fins they are supported by fin-rays (actinosts) and supporting bones (actinophores), but the latter do not enter into direct union with the vertebral column, although it is probable that they have a metameric significance here as well as there. The actinophores of both anterior and posterior fins acquire independent supports, which in the sharks are merely two unsegmented arches of cartilage whose convexities lie on the ventral surface of the body, but which give rise to the pectoral and pelvic arches of higher vertebrates.

It is comparatively easy to understand how the skeleton of the anterior and posterior fins of a shark-like form might be converted into that of a bony fish, but it is somewhat more difficult to understand how the limb skeleton of the higher vertebrate is comparable therewith. Nevertheless the condition in the shark forms the best starting point for the discussion of the paired limbs of the vertebrate branch. What this is may be seen from Fig. 27. The cartilaginous pectoral arch is composed of a right and left half intimately united in the ventral middle line. Half way up, three basal cartilages are attached to it on either side, supporting the cartilaginous rays, which again run out into the finer thread-like rays of the fin. The basal cartilages are known as pro-, meso-, and meta-pterygium, but it is to be noted that the propterygium is secondarily dorsal, not anterior, while the metapterygium is ventral, not posterior in position. This implies a rotation of the anterior edge of the fin through an angle of 90°. Most of the rays are attached to the metapterygium, very few being on its ventral (primitively posterior) edge. The pro- and meso-pterygium may be regarded as rays which have lost their attachment to the metapterygium, and have acquired new importance by attaching themselves directly to the pectoral arch, while the metapterygium forms the principal axis, giving origin to rays which are chiefly attached to its anterior border. The posterior fins of the sharks are essentially constructed on the same type as the anterior, although they are decidedly less altered from the primitive condition.

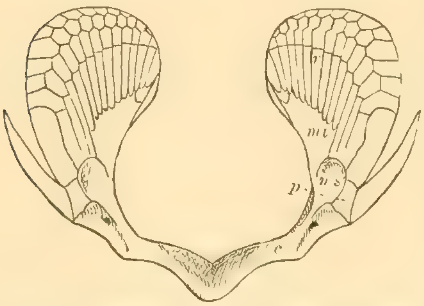


FIG. 27. — Pectoral girdle of a shark (*Scyllium*); *cr*, coracoid; *ms*, mesopterygium; *mt*, metapterygium; *p*, protopterygium; *r*, radial cartilages.

In respect of the structure of the limbs as well as in other anatomical features, the sturgeons are intermediate between the sharks and the bony fishes. The latter are characterized by the reduction of the parts corresponding to the above described cartilages, which results from superficial bones developed in the skin, having largely usurped the function of these. This remark is especially applicable to the pectoral arch, the investing bones of which (developed in part round that portion of the neuromastic tract which ascends from the lateral line to the head) constitute the great bulk of the shoulder-girdle in these forms.

It is very much otherwise in the higher vertebrates. In these the primary cartilaginous structures persist as the pectoral and pelvic girdles, which we may now shortly consider in the turtles, whose limbs retain many primitive features, as a convenient

starting point. In all of the higher forms we no longer meet with an undivided arch, but the point of attachment of the limb (glenoid fossa on the pectoral, acetabulum on the pelvic girdle) divides the cartilage into upper and lower regions (Figs. 28, 29). The upper is styled scapula in the pectoral, ilium in the pelvic girdle. While the dorsal end of the scapula is unconnected with the vertebral column, the ilium acquires such a connection by the intervention of one or more pairs of sacral ribs. Although the number of sacral vertebræ so formed is primarily small, the ilium may coalesce with vertebræ in front of and behind them, in such a way as to secure a great amount of solidity in this region, as is the case with the birds. The region of cartilage below the attachment of the limb generally ossifies in two pieces, an anterior and posterior, between which in all forms, except Amphibia, a fenestra occurs. In the pectoral girdle, the bone in front of the fenestra is termed precoracoid or clavicle, that behind it, the coracoid; and these elements correspond respectively to the pubis and ischium of the pelvic girdle, which are similarly related to the fenestra there. Connecting the elements of either side in the middle line, we find in many forms strips of cartilage (epicoracoid, symphysial) which may project in front into cartilaginous or osseous processes, styled respectively episternum and epipubis. The term episternum is suggested by the fact that in some Amphibia as well as in other reptiles and in birds, although not turtles, the coracoids acquire a secondary connection with the sternum, which persists in the monotremes, the mammals which are nearest the reptiles in their organization.

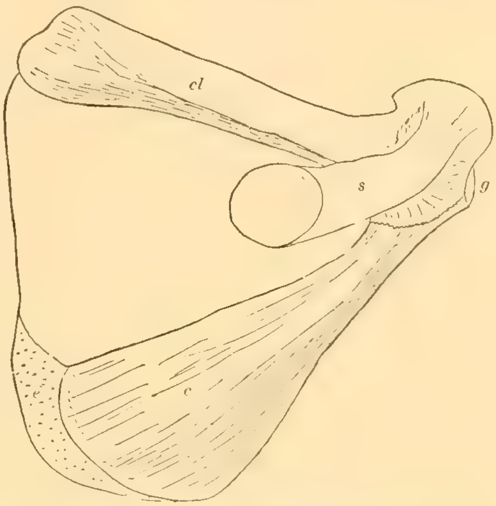


FIG. 28.—Half of pectoral girdle of turtle; *c*, coracoid; *cl*, clavicle; *e*, epicoracoid; *g*, glenoid fossa; *s*, scapula.

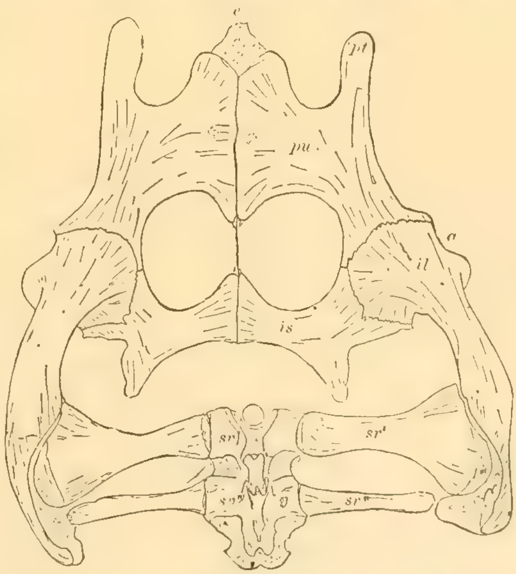


FIG. 29.—Pelvis of turtle; *a*, acetabulum; *e*, epipubis; *il*, ilium; *is*, ischium; *pt*, pectineal process; *pu*, pubis; *sr*, sacral ribs; *sv*, sacral vertebræ.

The condition of these parts in the other reptiles and Amphibia will be readily understood from the foregoing description, but some reference is necessary to the modifications characteristic of birds and mammals.

The pectoral arch in birds is characterized by the stoutness of the coracoid element, and the slenderness of the clavicular. The latter is developed partly in membrane, and the clavicles of opposite sides meet in the ventral, middle line,

forming the so-called furcula, 'wish-bone,' or 'merry-thought.' This is generally bound to the crest of the sternum, a part of the bone which is largely episternal in its nature. In mammals, on the other hand, the coracoid is, except in the monotremes, merely a hook-like process of the scapula; the latter usually develops a ridge or 'spine' for muscular attachment, terminating in an acromion process, to which the dorsal end of the clavicle is attached, while the ventral end of each clavicle is attached to the sternum by means of the intervention of more or less important remnants of the episternum (Fig. 15). Near these, remnants of the epicoracoid also persist, especially in the monotremes where the episternum is of large size, and forms a T-shaped 'interclavicular' support for the clavicles. We have referred above to one of the chief peculiarities of the pelvis in birds, the forward and backward extension of the ilia and their fusion with the long sacrum. The ventral region also offers many peculiarities, the chief of these being the backward direction of the pubis, and the wide separation of the ischia. There is consequently no symphysis or epipubis in these forms. Certain fossil Dinosauria have a double pubis, the anterior branch of which appears to be comparable to the pubis of other reptiles, while the posterior branch is homologous with the pubis of birds, in which the anterior branch is merely represented by a 'pectineal' process of the pubis. It is fairly certain that the pubis in mammals is likewise comparable to the posterior and not to the anterior branch of the dinosaur pubis, and it is possible that the so-called marsupial bones, well developed in monotremes and marsupials, and present rudimentarily in some higher mammals, may be comparable to the anterior branches, and not to the epipubis of other reptiles.

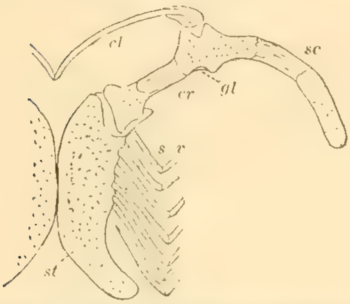


FIG. 30. — Pectoral girdle of embryo bird, *cl*, clavicle; *cr*, coracoid; *gl*, glenoid fossa; *s*, sternal ribs; *sc*, scapula; *st*, sternum; *r*, vertebral ribs.

In adult mammals the three elements of the pelvis unite to form an innominate bone, both the ventral elements of which unite in a symphysis in the lower forms, while in the higher forms the pubes alone do so.

If the anterior and posterior extremities of a snapping turtle be compared, many points of agreement will be readily detected. Each is divisible into three regions, supported by similar bones. Thus in the proximal region we have the humerus of the anterior extremity represented by the femur of the posterior; in the middle region the radius and ulna of the one represented by the tibia and fibula of the other; and in the distal region the skeleton of the 'manus,' or hand, containing similar bones to that of the 'pes' or foot. All of the vertebrates except the fishes are characterized by similarly arranged limb skeletons.

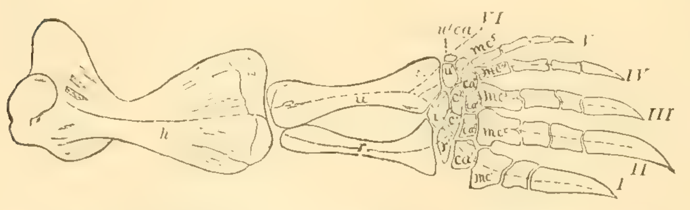


FIG. 31. — Fore limb of turtle; *c*, centralia; *ca* 1—5, carpals; *h*, humerus; *i*, intermedium; *mc* 1—5, metacarpals; *r*, radius; *r'* radiale; *u*, ulna; *u'*—*''*, ulnare; *I*—*VI*, digits, the sixth imperfect.

A close inspection of the manus discloses two rows of small bones succeeding the radius and ulna. These are the proximal and distal carpals, of which nine or ten at

most are present throughout the vertebrate series, but generally a less number, by reason either of the fusion of separate elements, or of the loss of such. In the proximal row we find first an 'intermedium' wedged in between the radius and ulna, then a 'radiale' and an 'ulnare' corresponding to the ends of these bones, and separated by one or two 'centralia.' In the next row are five distal carpals, numbered 1 to 5, from the radial to the ulnar side, and corresponding to the separate digits. The skeleton of each of these is formed of a metacarpal followed by a row of phalanges.

The nomenclature of the corresponding parts in the posterior extremity differs but little from the above. Here also we have an intermedium, then a tibiale, fibulare, one or two centralia, and finally five distal tarsals, followed by the metatarsals and phalanges of the toes. From the Amphibia upwards to the Mammalia the structure of the limb skeleton forms one of the most interesting chapters in comparative anatomy. It is impossible within the bounds of the present introduction even to outline the remarkable modifications to which it is subject. Suffice it to say that these are always in direct response to the nature of the use to which the limb is put, and consist either in the great development of certain elements in comparison with others, in the fusion of primitively separate elements, in the loss of such, or in all three combined.

Instead of the terms described above for the carpals and tarsals, others derived from human anatomy are frequently employed, especially in the group of the Mammalia. The subjoined table exhibits how these correspond.

Anterior Extremity.		Posterior Extremity.	
Radiale	Scaphoid	Tibiale	Sesamoid
Intermedium	Semilunar	Intermedium	Astragalus
Ulnare	Cuneiform	Fibulare	Calcaneum
Centrale	Central	Centrale	Navicular
Carpale 1	Trapezium	Tarsale 1	Cuneiform 1
" 2	Trapezoid	" 2	" 2
" 3	Magnum	" 3	" 3
" 4 } " 5 }	Unciform	" 4 } " 5 }	Cuboid

Those familiar with human anatomy will observe an apparently additional bone in the carpus (the central); one in the tarsus (the sesamoid), and one deficient in the carpus (the pisiform). The nature of the last will be presently referred to; as to the central, although independent in the adults of many mammals, it is only separate in the human fœtus, being afterwards, except in rare instances, absorbed in the scaphoid. The sesamoid is an independent bone in some mammals, but is generally absorbed in the navicular, which accordingly is usually equivalent to the centrale + tibiale.

A different interest attaches to the pisiform bone; it is to be regarded as a rudiment of a sixth digit on the ulnar side of the manus, and is represented also in most turtles as well as on the corresponding border of the pes in some tailed amphibians. Of rarer occurrence is a rudiment of a sixth digit on the tibial side of the pes, but the monotremes, as well as certain rodents, possess one.

If the dotted lines in Fig. 31 be now studied, it will be apparent that it is possible to represent the bones of the manus or pes as a principal axis, like the metapterygium of the selachian fin, giving rise to a series of radially arranged pieces. The axis is here represented as passing through the humerus, ulna, intermedium, carpale,[1] and the radial digit (pollex or thumb). There is abundant evidence to show that the radial border of the limb of the higher vertebrate is comparable to the metapterygial border of the selachian fin, but there is also evidence in the development of the tailed am-

phibians to show that the radius itself is not part of the principal axis, but a secondary axis developed beside it in response, perhaps, to terrestrial locomotion.

THE MUSCULAR SYSTEM.

Muscular tissue is characterized by the property of contractility, which may be evoked by a stimulus applied directly to the muscular fibres, or conveyed to them through the channel of nerve fibres. In the latter case the stimulus may be transmitted consciously by the will, or it may be entirely involuntary. A large proportion of the muscular tissue which is not directly under the control of the will differs from that which is, in being histologically simpler, and in replying less quickly to a stimulus. A rough distinction of voluntary and involuntary muscles is thus made, the latter being exemplified by the minute muscles in the skin which erect the hairs, etc., and by the greater masses of tissue which effect the propulsion of the food along the alimentary canal, and of the blood through the vessels.

The muscles which we discuss under this heading, however, are those that are connected directly or indirectly with skeletal parts, and which bring about change of relative position of these. They constitute the flesh or musculature of the body, and are of course chiefly employed in locomotion and prehension. It is only comparatively recently that much attention has been given to this branch of anatomy — Myology, as it is called — but it is obvious, from what has been said above, that the most intimate connection exists between this study and the study of the bones to which the muscles are attached, as well as of the motor nerves which end in the muscles.

Reference has already been made to the fact that the muscular system partakes in the segmentation of the body. This can be seen in its most unaltered condition in a fish (Fig. 10), where the flesh is divided up into muscle-flakes or segments (myotomes) separated by membranous partitions or septa (myocommata). When the latter are dissolved by boiling, the flesh readily separates into the flakes, the surfaces of which are often much curved, so that several different flakes appear in the same frontal plane (Fig. 11). In addition to these flakes which constitute the musculature of the trunk, there are other muscles also segmentally arranged in connection with the unpaired fins, but it is not so easy to detect a segmental arrangement in the muscles which perform the more complicated movements of the jaws, the gill-skeleton, and the paired fins.

With the change to terrestrial life, the paired limbs, taking on the function of the support of the body, become more complicated in their skeletal parts, and consequently also in the muscles destined for their movements. How multifarious these movements are can only be realized by reflecting on the extremely different uses to which the paired limbs are put, in prehension and locomotion. The various kinds of the latter, whether terrestrial, arboreal, aërial, or aquatic, are accompanied by corresponding modifications of the musculature. It is possible, nevertheless, to detect homologies by careful study of the nerve supply, as well as of the points of attachment (origin and insertion) to the bones. The latter feature is that which ought to determine the nomenclature of muscles, although general terms expressing action, such as abduction, adduction, flexion, and extension are convenient and in frequent use, and are sometimes, indeed, modified so as to designate the aspect of a limb on which particular groups of muscles are situated. Thus the biceps muscle occupies the 'flexor' surface of the arm.

The only guide as to the origin of the limb-muscles from particular segments of

the body is to be found in the origin of the motor nerves which supply them. These are, however, interwoven in a very complex manner (forming the brachial and sacral plexuses of spinal nerves) before they are distributed to the muscles of the fore and hind limbs. It is somewhat easier to detect segmental arrangement in the muscles of the trunk of higher vertebrates. They are no longer simply disposed in myotomes, but are differentiated into groups and layers capable of effecting more complex movements; and this differentiation is of course greatest in those regions — such as the neck — where the most complex movements are necessary. The muscles are not confined to the outer surface of the skeleton, but certain very important muscles are attached to the ventral aspect of the vertebral column. To this system belongs the diaphragm, a muscular partition, complete only in mammals, dividing off the chamber containing the heart and lungs from that containing the rest of the viscera.

Although the branchial skeleton largely disappears from the higher forms, yet it cannot be said that the musculature of the head becomes simpler in these, for the development of a tongue is accompanied by a corresponding development of the muscles attached to the hyoid bone — the representative of the branchial skeleton of the lower forms. The muscles of the jaws belong naturally to the same series of those of the rest of the visceral skeleton, but are specialized in the same degree as the bony framework to which they are attached.

While a considerable part of the trunk muscles on the dorsal aspect are derived from the conversion of part of the walls of the mesoblastic somites — the muscle-plates, the muscles of the lateral and ventral regions are derived from the lateral plates of the embryo. In the head, on the other hand, some of the mesoblastic somites give rise to no muscular structures at all, while others (the three foremost) give rise only to the small muscles which move the eyeball. The greater part of the musculature of the head is thus derived from the parts corresponding to the lateral plates in the trunk.

In addition to the fibres of involuntary muscles which are present in the skin, there are present in higher forms muscles which, arising generally from deeper parts, are attached to the skin, and have the function of moving it. Such are the muscles of expression of mammals, as well as larger sheets which may extend over considerable tracts of the body. The spines of the porcupine are erected by such muscles, which are also those employed by the mammals generally in shaking the coat.

THE NERVOUS SYSTEM.

Three constituent portions may be distinguished — the central nervous system, the peripheral nervous system and the connecting nerves. The last serve merely to transmit outwards or inwards (centrifugally or centripetally) messages between the central and peripheral systems. The latter is composed of the end organs of the centrifugal and centripetal nerves. We have already considered some end organs of the centripetal nerves — the lower sense-organs of the skin — and we shall describe the higher sense-organs at the close of this chapter. The ends of the centrifugal nerves are in the muscles, whether of the body, intestine, or blood-vessels, and likewise in the various glands, which are thus excited to secretion.

Only nerve-fibres are met with in the nerves, while nerve-centres or ganglia are characterized by the presence of nerve or ganglion cells in addition. It is customary

to distinguish between the cerebro-spinal and the sympathetic nerve-centres, but we shall see that the latter system is very closely connected with the former in development, so that we have first to consider the spinal cord and brain, which together constitute the cerebro-spinal nerve-centres, and then briefly the nerves in connection with these organs.

In the preliminary account of the development of vertebrates, the central nervous system was first seen in the form of a plate of modified epiblast — the medullary plate — which then became grooved and eventually transformed into a tube, closed at both ends. Certain dilatations and thickenings of the anterior end of the tube result in the brain, while the spinal cord is formed by a more uniform differentiation in the rest of its length.

A comparison of Figs. 3 and 32 will show what the nature of this differentiation is. The cavity of the tube is represented by the now small central canal of the cord lined by the remains of the epiblast, while the rest of the epithelium has been converted into the white and gray nervous matter surrounding the canal. The distinction of color is due to the presence of nerve cells in the gray matter, which is chiefly aggregated about the central canal, while the white matter forms the more superficial substance of the cord. Two fissures running along the dorsal and ventral middle lines give a marked bilateral symmetry to the cord, which exhibits great uniformity in its thickness throughout, except where it tapers at the tail, and where, in the higher forms, two swellings give rise to the nerves for the anterior and posterior limbs respectively. The gray matter forms a crescentic outline on a transverse section of the cord, and nerve roots may be seen to extend inwards towards the horns of the crescent. A segmented appearance is given to the cord by the origin of the pairs of spinal nerves, and this segmentation extends to the gray matter, which is more abundant in the planes of the origin of the nerves than in the intermediate planes. The spinal nerves arise in pairs, the nerve of each side originating by two roots, a dorsal and a ventral. According to what is known as 'Bell's law,' the latter are purely motor, while the former are purely sensory nerves, and some structural difference can also be recognized, for the dorsal roots contain fine fibres and have a ganglion developed on them, while the ventral roots have coarser fibres and no ganglion. The roots join shortly after their origin, and give rise to mixed motor and sensory nerves, generally disposed in three branches, a dorsal branch to the parts lying dorsad, a ventral branch to the parts lying ventrad, and an intestinal branch to the contents of the body cavity. The last-named branch is ganglionated, and as the various ganglia of the intestinal branches become united with each other, a double ganglionated chain results on the ventral aspect of the vertebral column — the sympathetic nervous system.

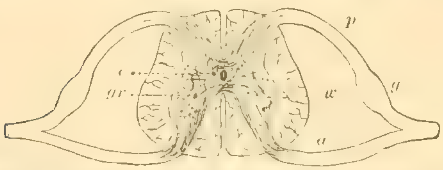


FIG. 32.— Diagrammatic section of spinal cord of mammal; *a*, anterior, *p*, posterior root of spinal nerve; *c*, canal; *g*, ganglion; *gr*, gray matter; *w*, white matter.

Much more complex are the changes which affect the anterior end of the neural tube, and which result in the formation of the brain or encephalon. At a very early period three dilatations appear, which are known as the three primary cerebral vesicles, but the first and third of these soon become subdivided in such a way as to render five regions distinguishable, which are known as the prosencephalon, thalamencephalon, mesencephalon, epencephalon, metencephalon. The cavities of these regions,

known as ventricles or cœliæ, communicate with each other, and with the central canal of the spinal cord. They are distinguished as prosocœle, thalamocœle, mesocœle, epicœle and metacœle, and instead of being uniform in diameter, like the central canal of the cord, differ very much from each other in configuration. The same is true of the walls of these various cavities, the growth in thickness of which is by no means uniform, so that the floor of such a cavity may be very thick, while its roof is extremely thin. So also the five regions do not ultimately retain an approximately equal size, but one or other becomes developed in excess of the others, so as to overlap them. Another modifying factor in determining the shape of the brain is the marked bend in the head of the embryo, which brings the mesencephalon to occupy its extreme anterior end, and which simultaneously shortens the floor of this region of the brain.

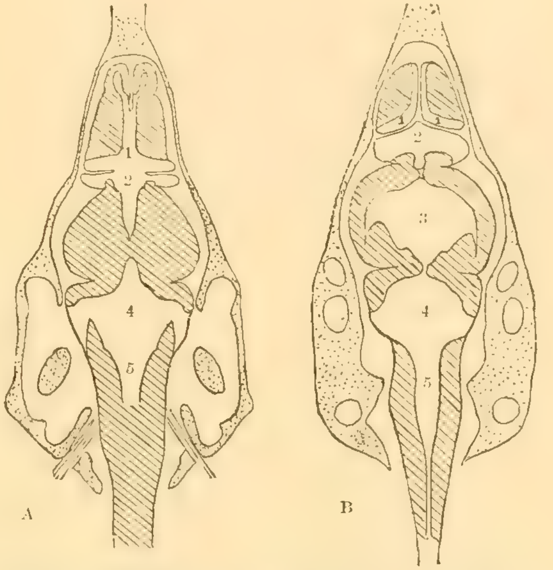


FIG. 33.—Horizontal sections through head of young gar-pike, *A* on a lower, *B* on a higher plane; chondrocranium dotted; brain with diagonal shading; 1, prosocœle; 2, thalamocœle; 3, mesocœle; 4 epicœle; 5, metacœle.

As we regard that part of the skull in front of the notochord as different from the hinder part, so we may distinguish the prechordal part of the brain from the hinder epichordal part, the limit between the two being approximately that between the floor of the thalamocœle and mesocœle.

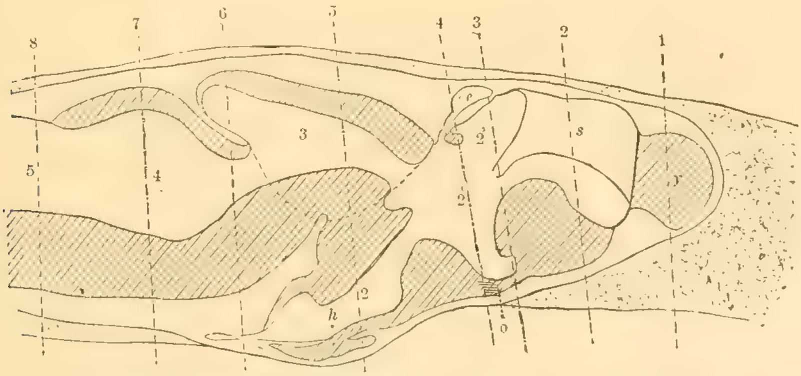


FIG. 34.—Mesal sagittal section of gar-pike's brain. The dotted lines, 1—8, indicate the positions of the frontal sections in Fig. 35; *r*, rhinencephalon; *s*, thin septum of prosocœle; *o*, optic nerve; 2, thalamocœle; *e*, epiphysis; *h*, hypophysis; 3, mesocœle (the curved dotted line indicates the limits of its floor); 4, epicœle; 5, metacœle.

Instead of a mere diagram to explain the relationship of the various regions of the brain to each other, Figs. 33 to 35, which represent sections in different directions through a comparatively primitive brain — that of the gar-pike — will serve as an ad-

mirable introduction to the study of this complicated organ. In a horizontal section like that shown in Fig. 33 B, the various cœliæ are seen communicating with each other, and with the central canal of the cord; only the prosocœle (1) appears in this plane, shut off and divided into two separate cavities, the walls of which are the 'cerebral hemispheres.' It will be observed, however, from Figs. 33 A, and 35, 2, that the prosocœle really does communicate with the thalamocœle behind, and that the thin double septum which dips down into it is only partial. It is further instructive to notice that only the lateral walls and the floor of the cavity are thick; both roof and septum are very thin, and between the folds of the latter a thin sheet dips down from the vascular membrane (*pia mater*) which everywhere closely surrounds the brain, and transforms the septum into a nutritive organ for this part of the brain, known as a choroid plexus. Such thin places in the walls of the cœliæ are of great interest and importance, because, although thin in one animal, they may be extremely thick in another. Thus the roof of the prosocœle in man forms the greater part of the bulk of his brain. From Fig. 33 A it will be noticed that the prosencephalon gives off anteriorly two lobes, the olfactory lobes or rhinencephala, which are almost solid (Fig. 35), except for two cavities, the rhinocœles, which open into the prosocœle behind. Occasionally the rhinencephala are separated from the prosencephalon by long olfactory tracts, but generally they lie quite close to the brain.

From a study of these horizontal sections one would conclude that the walls of the thalamocœle are almost entirely thin, but that such is not the case an examination of Fig. 35, 4, and Fig. 34, will demonstrate. The former figure passes through the origin of the optic nerve from the thick walls of the thalamocœle (the *optic thalami*), and also through two thick cushions in the roof (*habenular ganglia*) which are situated on either side of a tubular process which here projects upwards from the cavity. The latter, the 'epiphysis,' or pineal body, can be best seen in the mesal sagittal section (Fig. 34), which is further well calculated to show that the planes separating the regions of the brain need by no means be frontal. Those between the thalamencephalon here and the regions in front and behind it are directed from above and in front, downwards and backwards, so that sections 3 and 5 (Fig. 35), cut through parts of the thalamencephalon as well as the pros- and mes-encephalon respectively. This overlapping is perhaps more marked ventrally, where the thalamocœle runs back into a long 'infundibulum,' connected with the ventral wall of which is the 'hypophysis' or pituitary body. Both epiphysis and hypophysis appear to be functionless organs in adult vertebrates; their morphological significance we shall return to afterwards.

It was noted above that the roof of the mesocœle (3) becomes considerably developed owing to the cephalic flexure. This development persists even after the straightening out of the flexure, so that very little of the mesencephalon shows upon the base of the brain. The roof, however, may overlap the region in front and behind (Fig. 35, 6), giving rise to the prominences known as optic lobes (corpora bi- or quadri-gemina) throughout the vertebrate series.

Behind the mesencephalon the floor of the brain is remarkably uniform, and gives origin to most of the cranial nerves, but the roof is thickened in front into the 'cerebellum' (Fig. 35, 7), while it is thin further back (Fig. 35, 8). The difference in the roof renders it desirable to distinguish between an anterior epencephalon and a posterior metencephalon; the cavities of which epi- and meta-cœles, 4 and 5, freely communicate with each other. In mammals the cerebellum develops important lateral lobes which are connected with each other by a bridge-like commissure of nerve-fibres (the pons Varo-

lii), on the corresponding part of the brain-floor; this structure, when present, marks off also the floor of the epencephalon (pons) from that of the metencephalon (medulla oblongata), but the latter name is frequently employed for the floor of both regions in the absence of the pons.

The regions of the brain named above are as little 'segmental' in their nature as the regions of the skull already described. It is possible that all of the brain in front of the notochord (that is the thalam- and pros-encephalon) is merely an outgrowth of the epichordal part, and that consequently any trace of segmentation ought to be looked for in the latter. We have seen how the segmentation of the spinal cord is expressed by the origin of the spinal nerves, but the cranial nerves, although they originate in a similar manner from the neural tube, do not retain the primitive segmental arrangement, but acquire new connections with each other and with the brain, which renders the study of their segmental arrangement possible only in the embryo. It is not known how far the olfactory and optic (first and second) nerves, which

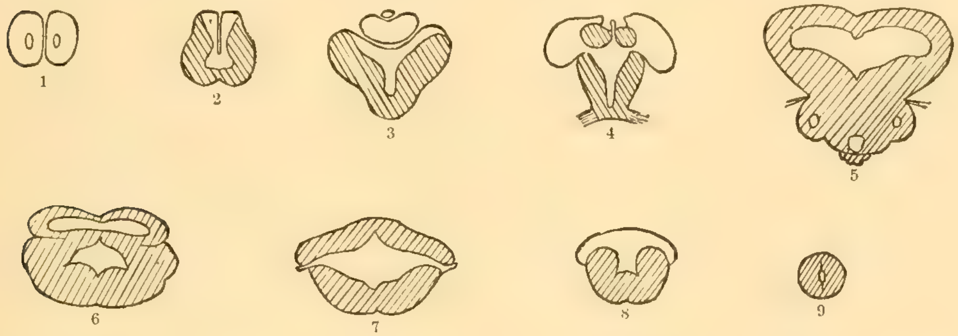


FIG. 35. — 1 - 8, frontal sections of brain of young gar-pike; 9, of spinal cord, through the planes indicated in Fig. 34.

originate from the prechordal brain (Fig. 37) agree with spinal nerves, but all the other cranial nerves are certainly segmental. This has been determined with most accuracy in shark-embryos, which exhibit more primitive conditions than those of higher vertebrates. In the notochordal part of the shark's head nine mesoblastic somites are present, the first three of which give rise to the muscles of the eye, the last three to certain muscles connecting the skull and shoulder-girdle, while the middle three do not develop any muscles. The cranial nerves have certain definite relations to these somites, which explains their distribution in the adult, but their relationship to the brain is somewhat different from that of the spinal nerves to the spinal cord. As with the spinal nerves, the ventral root is motor, but it proceeds merely to the muscles derived from the corresponding somite, not to those from the lateral plate below. The dorsal ganglionated root, on the other hand, is mixed, and not only contains sensory fibres, but motor fibres for the muscles derived from the lateral plate. It alone forms dorsal and ventral branches similar to those met with in the spinal region.

The destiny of the ventral and dorsal roots belonging to the different segments will now be intelligible. The ventral roots of the first three, forming respectively the third, fourth, and sixth cranial nerves, are distributed to the muscles of the eye, the ventral roots of the last three coalesce to form a nerve (known as the hypoglossus in sharks), which goes to certain muscles of the shoulder girdle, while there are no

ventral roots corresponding to the middle three segments. On the other hand, the dorsal roots of the first two segments give rise to the fifth (trigeminal) nerve, of the next two to the seventh and eighth (facial and auditory), of the fifth to the glosso-pharyngeal (ninth) nerve, and of the remaining four to the complex vagus (tenth) nerve. That these nerves cause no marked segmentation of the adult brain is abundantly apparent from Fig. 37, which shows how they originate in the brain of a turtle. A short reference is all that our space permits to the course of the dorsal and ventral branches of the dorsal roots. The former appear to be chiefly distributed to the neuromastic tracts, with the exception of the fourth, which forms the auditory nerve (vide supra, p. 8) while the latter course down the sides of the head, and, when they arrive at the visceral clefts, fork over these, giving a slender anterior branch in front of the cleft, and a stouter posterior branch behind. Intestinal branches are likewise given off, which correspond to the intestinal branches of the spinal nerves considered before.

In higher animals two other nerves primitively connected with the spinal cord, the spinal accessory (eleventh) and hypoglossus proper (twelfth) become associated with the ten pairs of cranial nerves referred to above.

Such a brain as that of the gar-pike forms a type from which the brains of other fishes and amphibians may readily be studied. In the higher classes, however, there is an ever-increasing tendency towards the supremacy of two regions of the brain over the others, viz., — the cerebral hemispheres and the cerebellum, — parts, it will be remembered, of the pros- and ep-encephalon. This tendency is not very much marked in the brain of the turtle (Fig. 37), but the prosencephalon even here is very much more developed than in the lower forms. The particular way in which this has taken place can be realized by comparing Fig. 36, which represents a horizontal section through the anterior end of the turtle's brain, with the representation of a similar section through the gar-pike's brain (Fig. 33). It will be observed that paired outgrowths are present from the prosencephalon in the latter, but the median walls and the roofs of these remain very thin, while in the turtle they are nearly as thick as the rest of the wall of the prosocœle. The lateral outgrowths in the turtle preponderate over the central undivided part, and they grow back beyond the latter so as to overlap even the mesencephalon. The ventricles or cavities of these lateral outgrowths remain in communication by wide 'foramina of Monro,' with the central part of the prosocœle (the aula), the anterior wall of which is known as the lamina terminalis of the brain. It will be observed that this lamina is of thickened nervous matter in the turtle, whereas in the gar-pike it is represented only by the posterior edge of the thin double septum of the prosocœle.

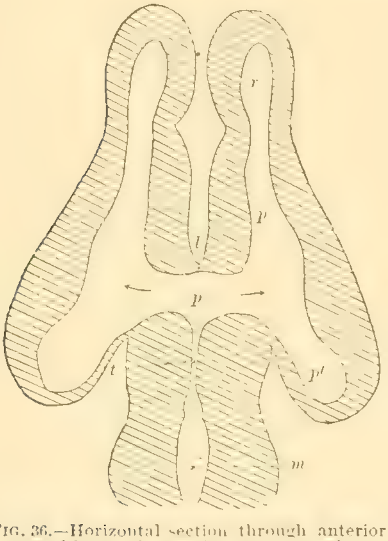


FIG. 36.—Horizontal section through anterior part of brain of a turtle; *m*, mesocœle; *t*, thalamocœle; *p*, aula, or axial part of prosocœle leading by the portæ or foramina of Monro (the arrows) into the anterior (p') and posterior (p'') cornua of its lateral 'ventricles' or procœles; *l*, lamina terminalis; *r*, rhinocœle.

The roof of the brain in the turtle is not unlike that of many lower forms, for the

thin roof of the thalamocœle is free on the upper surface; behind that are the optic lobes, or corpora bigemina, of the mesencephalon, succeeded by the comparatively small cerebellum and the thin roof of the metacœle.

A greatly advanced stage of development is to be met with in the birds (Fig. 38), the chief characteristics of the brain of which consist in the great size and shape of the cerebral hemispheres, which, growing backwards towards the cerebellum, cover the roof of the thalamencephalon, and cause the optic lobes to assume a lateral instead of a dorsal position on the mesencephalon. The cerebellum itself grows forward to meet the cerebral hemispheres, and backwards so as to overlap the thin roof of the metacœles, and develops on either side a small lateral lobe which becomes of far greater importance in the mammalian organ.

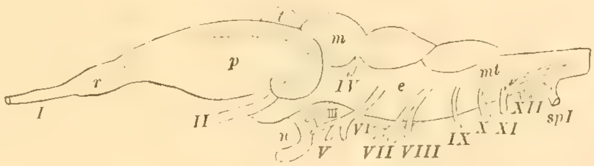


FIG. 37.— Side view of turtle's brain; *I* – *XII*, the cranial nerves; *spI*, the first spinal nerve; *r*, rhinencephalon; *p*, prosencephalon; *t*, thin roof of thalamencephalon; *h*, hypophysis; *m*, mesencephalon, or optic lobes (corpora bigemina); *c*, epencephalon with thick roof, the cerebellum; *mt*, metencephalon, with thin roof (choroid plexus).

So greatly are the cerebral hemispheres and the cerebellum developed in the mammalian brain, that the other regions are entirely dwarfed in proportion. This is true of even the lowest forms, but it reaches its maximum in man, where the cerebral hemispheres even cover the cerebellum, as well as all the intervening parts of the brain. Not only does this growth take place backwards, but also forwards, in front of the lamina terminalis, and downwards towards the base of the brain, so that the lateral ventricles, instead of being merely in front of the aula, are continued by so-called 'cornua,' into the lobes which result from the growth of the cerebral hemispheres in the directions indicated.

In all of the lower forms the right and left halves of the different regions of the brain are connected by bundles of nerve fibres, constituting transverse commissures; so also longitudinal commissures are present, connecting the various regions of the brain with each other. The mammalian brain not only possesses representatives of these commissural systems, but others are developed in response to the greater increase in importance of the cerebrum and cerebellum, which reach their maximum in man.

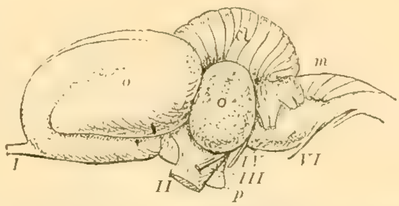


FIG. 38.—Brain of a gallinaceous bird; *c*, cerebrum; *cl*, cerebellum; *m*, medulla oblongata; *o*, optic lobes; *p*, pituitary body; *I*—*VI*, cranial nerves. (The cut ends of *V* and *VII*—*XI* are seen on the sides of the medulla.)

Of these we have already alluded to the pons Varolii, found on the ventral aspect or base of the brain, and serving to unite the lateral lobes of the cerebellum, which have become in the lower forms of as great size as the original middle lobe, while in the higher forms they greatly exceed it. Two other important commissures — the corpus callosum and the fornix — are developed in connection with the cerebral hemispheres; but these, instead of being within the cœliæ, like the commissures of the lower forms, are really outside this system of cavities. If a triangular patch of the median wall of each cerebral hemisphere be conceived to remain thin, and to unite with that of the other side, instead of being uniformly thick and independent from its neighbor, as in the turtle (Fig. 36), we shall realize the way in which the 'septum lucidum' of the mammalian brain is formed. Occasionally the union of the two halves of this thin septum is not complete,

in which case a little space in the septum is left, known in human anatomy as the fifth ventricle of the brain. It must be understood that it has really nothing to do with the true cœliæ, but is only a part of the great fissure which separates the two hemispheres. The corpus callosum and fornix have important relations to the septum lucidum, for the former is constituted by fibres crossing transversely between the right and left hemispheres of the cerebrum, in front of and above the level of the septum, while the latter arches upwards from the base of the brain behind the septum, and thus reaches the under surface of the corpus callosum. Concomitantly with the great development of the cerebral hemispheres and their ventricles, the other parts of the cœliac system become very much reduced in size. This is especially true of the aula, which is very small in the higher forms. The thalamocœle is known as the third ventricle, the epi- and meta-cœliæ together as the fourth, while the mesocœle is reduced to a mere 'iter' connecting the two, known sometimes as the aqueduct of Sylvius. The roof of the mesocœle undergoes a further subdivision than we find in reptiles and birds, being converted into four prominences instead of two, the corpora quadrigemina.

Of the greatest importance for the functional activity of the mammalian brain is the circumstance that in all except the lowest forms the surface, instead of remaining smooth, becomes much complicated by the development of fissures and intervening convolutions. This complication of the surface has for its object the accommodation of an increased amount of gray matter, for in the cerebrum, as well as in the cerebellum, the white fibrous matter is contained in the inside, while the gray matter containing the ganglion cells is superficial. The shape of these convolutions is very different in the cerebellum and cerebrum. In the former they are in regular foliations, which determine the curious method of distribution of the white matter, known as the arbor vitæ, while in the latter they are far less regular, although nevertheless always conforming to the same fundamental type in the same species. Of special interest in connection with the form of these convolutions is the discovery within recent years that particular functions are localized in parts of certain convolutions which are thus regarded as the cerebral centres of these functions.

In addition to the pia mater already referred to as carrying the vessels for the brain, there is an 'arachnoid' membrane bounding a lymph space immediately outside the pia, and a dura mater intimately connected with the skull, and in mammals sending partitions between the lobes of the brain, which contain the great veins necessary to drain away its venous blood. Sometimes the dural partitions referred to ossify, as in the case of that separating the cerebrum and cerebellum of many carnivores which possess an ossified tentorium cerebelli. Before leaving the brain, a few words as to the epiphysis and hypophysis cerebri (pineal or conarial and pituitary bodies) will indicate the present state of our knowledge of these remarkable organs. They are apparently functionless in all living forms, but are no doubt derived from structures perhaps of a sensory character, which were intimately related to the brain in the ancestors of the vertebrates. The epiphysis is a diverticulum of the roof of the thalamocœle, while the hypophysis is developed from the roof of the mouth, but is intimately related to a diverticulum of the floor of the thalamocœle. The relations of these two diverticula suggested to Owen and others that the intestine once communicated with the upper surface of the head through this 'conario-hypophysial tract,' and opened on the neural surface, as it does in arthropods. According to this theory the conario-hypophysial tract is the remains of a primitive œsophagus, and the

surrounding nervous matter corresponds to the supra- and infra-œsophageal ganglia, with their connecting commissures in the arthropods and annelids. There is little evidence to support this theory; it is far more probable that both epiphysis and hypophysis are rudiments of sense-organs which have become lost in the higher forms. It has been suggested that the epiphysis is a rudiment of an unpaired eye, projecting upwards from the thalamocœle, as do the optic vesicles laterally, and it is probable that the hypophysis is comparable to certain sense organs possessed by Amphioxus and the tunicates. The connection of the hypophysis with the mouth is very early lost, the duct disappearing entirely except in the Myzonts, where, in the most remarkable way, the ventral end of the duct shifts its position so as to open on the upper surface of the head instead of in the mouth. A further reference to this condition will be found in the description of the olfactory organs of these forms.

THE HIGHER SENSE-ORGANS.

The Auditory Organ.

All the higher sense-organs may be regarded as differentiated parts of the skin, the supplying nerves of which have become greatly specialized, and have thus acquired a more marked individuality than the other sensory nerves. The ends of the nerves are to be sought for in modified tracts of the epiblast, known as neuro-epithelial tracts, where they terminate in sensory cells, generally isolated from each other by indifferent cells. In the case of the olfactory and auditory organs these neuro-epithelial tracts are developed from hollow ingrowths of the ordinary epiblast of the head, but in the case of the eye the neuro-epithelium (retina) is formed as an outgrowth of the first cerebral vesicle, which, however, it must be borne in mind, is epiblastic in origin.

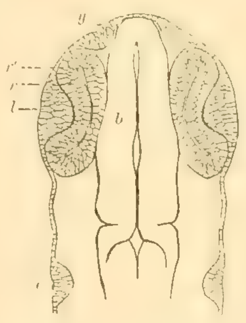


Fig. 39. — Head of embryo fish (*Ctenolabrus*); *b*, brain; *e*, invagination for ear; *l*, thickening of epiblast for the lens of the eye; *n*, nasal pit; *r*, *r'*, outer and inner layers of optic vesicle which later form the retina.

Surrounding the epiblast destined to form the neuro-epithelium there is always some mesoblastic tissue which carries the necessary vessels for the nourishment of the neuro-epithelium, and which likewise forms a more or less complete capsule for the organ. We have already seen what an important part these sense-capsules play in modifying the skull.

A fish forms a convenient starting-point for the study of the ear, because only the internal ear or auditory organ proper is present, without the additional drum cavity and external ear which we find in higher forms. The epiblastic ingrowth is at first sac-like (Fig. 40), but soon gives out processes which result in the highly complicated structure known as the auditory labyrinth. In sharks the auditory labyrinth is closely surrounded by the cartilage of the skull on every side, but in teleosts it is to a great extent free within the cranial cavity, owing to deficiencies in the inner wall of the capsule. It is consequently very easy to dissect out the labyrinth of an ordinary bony fish. The cat-fish will serve as an accessible type (Fig. 40). Here we recognize two parts, an upper and a lower; the upper composed of a vertical tube, the 'utriculus,' with a large anterior recess, with which are connected three semicircular canals, the lower of a less capacious 'sacculus,' also provided with a recess, — the 'cochlea.' Connecting the utriculus and sacculus is a narrow tube which in many cases is completely

closed in the adult. The original opening by which the cavity of the labyrinth communicates with the outside is closed in the adults of almost all vertebrates, but the sharks form an exception to this rule, the endolymphatic duct, as it is called, remaining permanently open. This duct is so named on account of the fluid endolymph contained in the labyrinth, the vibrations of which disturb the hairs projecting from the sensory cells into this fluid. The sensory cells are only accumulated at certain spots in the labyrinth, to which the branches of the auditory nerve are distributed; three of these are known as 'cristæ acusticæ,' and project into the 'ampullæ,' which terminate one end of each of the three semicircular canals, while three others are larger patches, 'maculæ acusticæ,' which occupy the recess of the utriculus, the sacculus, and the cochlea respectively. Resting on these three maculæ are certain ear stones or otoliths formed of dense calcareous matter, and known as the lapillus, sagitta, and asteriscus. Like the maculæ they vary much in form and relative size throughout the class of the fishes. Of the semicircular canals, two are vertical, while the third (external) is horizontal in position; the anterior of the vertical canals is approximately in a sagittal plane, the posterior in a frontal plane.

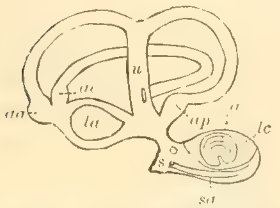


FIG. 40.— Auditory labyrinth of a cat-fish, right side inner aspect; *u*, utriculus; *la*, otolith in the recessus utriculi; *aa*, *ae*, *ap*, ampullæ of the anterior, external and posterior semicircular canals respectively; *s*, sacculus with otolith, *sa*. *l*, lagena cochleæ with otolith, *a*; *o*, near the utriculo-saccular duct, indicates point where a transverse tube effects a communication with the labyrinth of the other side in this and some other fishes.

The wall of the labyrinth is formed of a very delicate cartilage, lined by a low epithelium, except at the spots where the sensory cells are accumulated. A quantity of loose tissue containing fluid (perilymph) surrounds the labyrinth, and serves to transmit vibrations to the latter. The chief channel by which vibrations reach the ear in fishes is unquestionably the loose bones of the head and gill-cover, but there may be other channels, notably the air-bladder in the cat-fish and sucker, and their allies, while in some sharks the first gill-cleft apparently serves for this purpose.

The higher Vertebrata not only approach the sharks more closely in this respect than they do the ordinary fishes, but also in respect of the complete nature of the capsule surrounding the labyrinth. This capsule, at first cartilaginous, afterwards ossifies, and forms the osseous labyrinth, which agrees in all respects with the enclosed 'membranous' labyrinth in form, there being only a very narrow space, containing perilymph, left between the osseous capsule and its contents. The only deficiencies in the wall of the osseous labyrinth, apart from the aperture by which the nerve gains admission, are two holes on the lateral aspect, which look into the tympanic cavity or cavity of the drum of the ear, present, with few exceptions, among the higher vertebrates. One of these holes, the 'foramen ovale,' is opposite the sacculus, and is occupied by the inner end of the chain of bones that stretches across the tympanic cavity, while the other corresponds to the cochlea in position, and, being occupied by a tense membrane, is known as the 'fenestra rotunda.' It is chiefly through the chain of bones that sound-waves set the perilymph, and consequently the labyrinth which floats freely in it, in motion; although vibrations are no doubt also transmitted through the bones of the head.

Before referring more specifically to the method by which vibrations are transmitted to the labyrinth in the higher vertebrates, one or two points in which the labyrinth itself differs from that of the fishes must be referred to. In the first place, the otoliths which are so conspicuous in the fishes are barely represented among the

higher forms; and in the second place, the cochlea gradually acquires independence from the sacculus, and eventually becomes converted (in the mammals) into a spirally coiled tube, whence in fact it derives its name.

It has been mentioned above that vibrations may reach the labyrinth in some sharks by means of the first gill-cleft. In the smooth hound and similar forms there is a distinct recess of the cleft that stretches up towards the labyrinth. This is exactly what we find in higher vertebrates; only the gill-cleft itself disappears, and the recess stretches up from the cavity of the mouth in the form of the Eustachian tube, to terminate under the skin in a dilatation — the tympanic cavity — which lies to the outside of the osseous labyrinth. The portion of skin immediately over the cavity, being thin and tense, is subject to vibration, and may be either quite exposed on the side of the head, as in the frog, or at the bottom of a longer or shorter passage, the external auditory meatus, as in higher forms. An additional provision for collecting the vibrations towards the tympanic membrane is afforded by the external ear, which, however, reaches a high grade of development only in mammals.

The question now arises how the chain of bones which serves to transmit vibrations from the tympanic membrane to the labyrinth gets into the tympanic chamber. We saw above that it represents in all probability the suspensorial apparatus of the lower jaw in fishes, and further that the loose bones of the head in the latter group form an important channel by which vibrations reach the labyrinth. We may conclude from this that the function which the chain of bones performs in the higher vertebrates is inherited from lower forms, where they had, however, additional duty to perform. If it be also agreed that the Eustachian tube and tympanic cavity represent the recess of the first gill-cleft in a shark, then we may conclude that the higher vertebrates have inherited both the wave-transmitting recess and the chain of bones from some fish-like ancestor. The position of the chain of bones in the tympanic cavity can only be explained by assuming that the dilated end of the recess grows round the chain, enveloping it in such a way as to bring them within the cavity, but yet covering them on every side with mucous membrane as it does so.

The Eye.

The essential difference in the development of the eye from that of the other sense-organs — its neuro-epithelium being a direct outgrowth of the medullary epiblast — has been noted above. At a very early stage the first cerebral vesicle buds out on either side the optic vesicle, which, however, is soon converted into an optic cup by an ingrowth from the overlying skin to form the lens (Fig. 39). The lens is purely epidermal in its origin, and the little piece of mesoblast which it pushes before it becomes transformed into the vitreous humor, a clear gelatinous tissue which fills the cavity of the optic cup. The wall of the cup next to the lens becomes converted into the retina, *r* (Fig. 41), the other wall remains thin, and in fact only formed of a single layer of epithelium, but this acquires a distinctive character and an important function, by a deposition of black pigment in its cells, which then constitute the pigmentary epithelium of the retina. The cavity separating the two layers of the retina, at one time continuous with the thalamocœle, disappears, as does that of the optic stalk, which becomes converted into the optic nerve. Closely applied to the retinal epithelium is the choroid coat, mesoblastic in origin, and serving chiefly as a carrier of vessels for the nourishment of the eye, and of pigment. This coat has certain muscular fibres in it anteriorly (the ciliary portion), which partly serve to support

in position and alter the form of the lens, but also serve to regulate the admission of light to the eye by modifying the size of the pupil (the iris). Light is admitted to the eye through the cornea, a modified piece of skin, the mesoblastic layer of which is continuous with the capsule of the eye, or sclerotic coat. The latter is opaque, and cartilaginous or occasionally ossified in plates. Unlike the auditory capsule, it forms no integral part of the skull, although in some sharks it is continuous by a cartilaginous stalk with the cranial capsule.

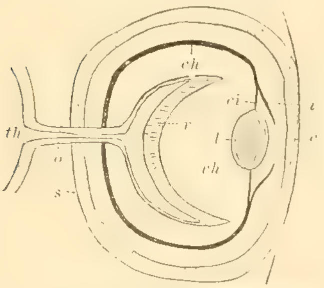


FIG. 41.—Diagram of vertebrate eye; *c*, cornea; *ch*, choroid; *ci*, ciliary process; *i*, iris; *o*, optic nerve; *r*, retina; *s*, sclerotic; *th*, thalamnocœle; *vh*, vitreous humor.

The eyeball, composed of the elements just enumerated, is surrounded in the orbit by a quantity of loose tissue which admits of free movement in different directions, under the control of the muscles attached to the sclerotic coat. These are generally six in number, four of them straight and parallel to the optic nerve, the remaining two oblique, and arising in the anterior angle of the orbit. We have already discussed the origin and innervation of these muscles. Protective folds of skin to cover the eyeball are developed in most forms above fishes, being rendered necessary by the change from aquatic life. These folds are the upper and lower eyelids, with frequently a third, which can be pulled over the eye from the anterior angle, and is called the 'nictitating membrane.' This is kept moist by the secretion of a special gland (Harderian), while the secretion of the lachrymal gland, which is situated at the posterior angle of the orbit, is being kept in constant motion over the surface of the eyeball by the movements of the eyelids proper. Between these and the surface of the eyeball is a space, the conjunctival sac, which is put in communication with the nasal cavity by the lachrymo-nasal duct, through which the tears are drained into the nasal cavity.

Before leaving the eye it is necessary to consider shortly certain structures of restricted occurrence within the vertebrate series. Many bony fishes have an important vascular organ, the choroid gland, formed round the optic nerve after it has pierced the sclerotic, the function of which is very obscure. It will be more convenient to refer later to the mode in which it is supplied with blood. Another structure, of the nature of a vascular plexus, is the pecten of reptiles and birds: it projects into the vitreous humor, and may be considered to replace the absent vessel of the retina in the forms which possess it. The obstruction which the blood meets with in flowing through such a vascular plexus leads to the effusion of nutritive material through the thin walls of the vessels of the plexus.

Immediately outside the retina, certain structures are developed within the choroid coat, which appear to have the function of rendering that coat more impervious to light. Such are the 'tapeta' of many fishes and of some mammals. The focussing of the lens is not always secured by the ciliary part of the choroid coat, but there may be a special muscular falciform process projecting into the vitreous humor, and grasping the lens, as in the case of most bony fishes.

Apart from the presence or absence of vessels referred to above, the retina may exhibit other structural differences within the different groups. In the retina there is a considerable quantity of indifferent isolating material, which serves for the support of the really nervous elements, and which corresponds to the neuroglia of the brain. The elements which are directly acted upon by the light are the rod-like or cone-like

ends of the neuro-epithelial cells, which at first look into the cavity of the optic vesicle, but, when that disappears, become surrounded by branched outgrowths of the pigmentary epithelial cells, which furnish the rods and cones with the sensitive visual purple. The relative proportion of rods and cones is very different in different groups, and their structure is likewise different — those of the reptiles and birds being particularly remarkable for the brilliantly colored drops of oil which are present in them.

The Olfactory Organ.

Like the auditory organ, the olfactory organ first appears as an involution of the skin. It is represented by a ciliated sac in Amphioxus, the position of which is such as to suggest that the organ was related to the anterior end of the open neural canal in the earliest vertebrates, a theory which would explain the source of its nervous supply by the extreme anterior end of the prosencephalon. If correct, this theory would lead us to believe that the unpaired sac met with in Amphioxus and the Myzonts is the primitive condition, and that the paired condition in higher vertebrates is secondary. A very remarkable difference exists between the nasal organ of the hag-fish and the lamprey, which merits attention. In the latter fish the olfactory mucous membrane is lodged in an unpaired sac, opening on the upper surface of the head, by means of the remnant of the hypophysial duct referred to above, and has no communication at all with the cavity of the mouth, while in the former, the hypophysial duct forms a complete tube leading from the upper surface to the cavity of the mouth, and the olfactory mucous membrane is lodged in a posterior recess of this tube. The connection between the nasal and mouth cavities, which obtains in the higher vertebrates, is brought about in a very different fashion.

In fishes generally, the olfactory sacs are paired, and lined with mucous membrane disposed in folds, in the grooves between which the special sensory cells are lodged, while the surfaces of the folds are merely clad by ciliated cells which cause a current to stream over them. The roofs of the sacs are frequently strengthened by bone, and there are generally two apertures, often quite close to each other, which may be prolonged into tubes, through which the current makes its entrance and exit.

In certain forms the folds are so disposed as to have created the impression that the olfactory sacs might represent a pair of modified gill-clefts with contained filaments, but the theory of their origin, referred to above, is that which is more generally adhered to.

In sharks a groove leads from the olfactory organ to the mouth, and no doubt this is the first representative of the similar groove which connects on either side the olfactory pit, and the cavity of the mouth in higher forms, and which afterwards is closed into a canal leading from the olfactory sac into the mouth cavity. The posterior apertures of these canals form the posterior nostrils or choanæ; they are situated directly behind the upper lip in Amphibia, but, by the development of the shelf of the palate referred to above (p. 18), gradually shift further backward until they occupy a position far back in the cavity of the mouth.

Mention has already been made of the complex turbinal surface afforded for the olfactory mucous membrane by the nasal capsule. Only part of the cavity is occupied by the olfactory neuro-epithelium, the rest serving as a channel for respiration in the higher forms, where the posterior nostrils are brought into close relation with the top of the windpipe. The whole mucous surface is provided with glands, which furnish the moisture necessary to preserve the functional activity of the epithelium. A re-

markable recess of each nasal sac is well developed in the snakes and lizards, and in some mammals. It is known as the organ of Jacobson, and is situated between the roof of the mouth and the nasal sac. It is to be regarded as a very specialized part of the olfactory neuro-epithelium, being abundantly supplied with branches from the olfactory nerves.

THE INTESTINAL SYSTEM.

In all Vertebrata, part of the anterior region of the intestinal canal is devoted to the function of respiration, the organs in connection with which will form the subject of a special section. Here only those parts of the intestinal system which are connected more or less directly with the elaboration of the food will be discussed. The formation of the cavity of the mouth, by the turning in of a pit of epiblast, has been already referred to; the anal end of the tract is similarly formed in many animals, but the rest of the tract is lined by hypoblast in its whole extent, which gives rise to the cells engaged in secretion. Associated with the hypoblast, which in the greater part of the tract is only one cell thick, there is the layer of mesoblast (p. 5) from which is formed the vascular connective tissue, on which the hypoblast rests, as well as the muscular tissue which constitutes the greater part of the thickness of the intestinal wall. Covering the muscular tissue on the outside is a fibrous membrane, clothed with flat endothelial cells, which is continuous by a double dorsal fold (the mesentery), with the similar membrane which lines the inner surface of the body-wall. This is the cœlomic or pleuro-peritoneal membrane, the 'parietal' layer of which lines the body-wall, while the 'visceral' layer clothes the viscera, which lie in the cœlom.

The following regions are recognizable in the alimentary canal of all vertebrates: the cavity of the mouth and pharynx, the œsophagus and stomach, the small intestine, and the large intestine. No well-marked boundary exists in many forms between the pharynx and the œsophagus, but the stomach is generally marked off from the small intestine by a distinct pyloric valve, while a similar valve (ileo-cæcal) between the small and large intestines likewise prevents the backward passage of the food.

From their position we should expect the aperture and cavity of the mouth to be subject to extremely wide modifications. These being always such as are adapted to the food, the modifications are as infinite in their variety as the food itself. To realize this it is only necessary to think of the remarkable differences in this respect between the animals with which we are most familiar. The aperture of the mouth or gape, with its bony framework, is liable to just as much modification as the organs contained in the mouth cavity. It is only in the mammals that we find fleshy lips forming a vestibule in front of the bony framework, but this, in certain cases, where cheek pouches are present, may be an important part of the alimentary tract.

Within the cavity of the mouth are developed certain organs which secure the food, or masticate it, or propel it into the œsophagus, or chemically alter it. These are the teeth, the tongue, and the salivary glands.

We have already seen how teeth are developed, and how cement bones formed in connection with them contribute in a most important manner to the formation of the bony walls of the mouth. The tendency to be observed as we proceed from the lower to the higher animal is to the restriction of these teeth to definite tracts, eventually to the bony margins of the gape, and gradually to specialization not only in number but also in form. The description of the teeth forms such a readily accessible

structural feature for the systematic zoologist, especially in the case of the mammals, that a full description of the dental system of the different groups will be found under these. The student will thus be able to test the law of gradual specialization to which reference has just been made, and will find that it applies within the smaller groups, as also in proceeding from the lower to the higher classes.

The second of the series of organs enumerated above — the tongue — is to be regarded as a fold of the mucous membrane of the floor of the mouth, supported by the basihyal bone, or its anterior glossohyal process. In most fishes it is nothing more, but in Amphibia and the higher classes, muscular tissue enters into its formation, and it becomes functional in securing the food, and moving it about within the mouth cavity. The muscles are partly confined to the fold (intrinsic), and partly attached to the hyoid skeleton (extrinsic), but both form the great bulk of the tongue, comparatively little glandular tissue entering into its formation. It was observed above that the end buds, which are more uniformly distributed in fishes, are confined to the cavity of the mouth in higher forms; the tongue is their usual seat in mammals, where they constitute the organ of taste, and are arranged on papillæ of peculiar form.

In shape the tongue is subject to much variation; it is sometimes developed equally in all directions round its surface of attachment, but its free portion generally extends either forwards or backwards from that point. Thus, in the frogs, the tongue is attached anteriorly, and its posterior bifid end is that which is thrust rapidly out in securing insects. Again, in mammals, it is attached behind and free in front. Frequently thick and fleshy in appearance, it is in many forms slender and cylindrical; generally covered with a soft mucous surface, it becomes, in the birds, coated with a horny layer, in adaptation to entirely different uses. Its highest degree of specialization in one direction is reached in man, where it enters into important functional relations to the organs of voice and speech.

The glands which open into the cavity of the mouth, secreting the saliva for admixture with the food, are not represented in the fishes, although they are present throughout all of the higher groups. In the Amphibia and some reptiles they form more or less continuous tracts, which, however, become restricted to particular spots in the higher reptiles, birds, and mammals. The chief of these are the submaxillary and sublingual glands in the floor of the mouth, the buccal and parotid in the lateral walls. The secretions furnished by these glands are of two kinds, and are formed by cells of different histological character, either they facilitate the swallowing of the food, or they act upon it chemically; but both forms of gland-cells may be united in the same gland. Special functions are sometimes met with, as in the case of the anteaters, where the submaxillary glands furnish the sticky secretion which aids the tongue in securing their insect food, or in case of the venomous snakes, where the parotid gland becomes an organ of offence and defence, being converted into the poison-gland. A similar change of function of the ordinary cutaneous glands we have met with in the group of the Amphibia.

Before proceeding to describe the divisions of the alimentary canal, a short account of its structure may be useful. Various coats are distinguished, of which the outermost (which looks into the cœlom) is the pleuro-peritoneal membrane. Immediately within this is the muscular coat, composed of two layers of generally unstriped fibres which are disposed longitudinally in the outer, but circularly in the inner layer. The muscular coat is connected with the innermost mucous coat by a submucous layer of connective tissue, which contains the larger blood vessels and nerves. The smaller

vessels and nerves are distributed in the mucosa proper, and this is clad on the free intestinal surface with the hypoblastic cells, generally disposed in a single layer.

That portion of the alimentary canal concerned more directly with the elaboration of the food is, as we have seen, divided into three regions by two well-marked valves — the pyloric and ileo-cæcal. The former separates the first region comprising the œsophagus and stomach from the small intestine, the latter the small from the large intestine.

Even in forms which are nearly allied to each other, considerable differences may be observed as to the proportionate length of the intestine. These are attributable to difference in the nature of the food; as a rule carnivorous forms have a simpler and shorter intestinal tract than those which are dependent entirely on vegetable food. An instructive illustration of this principle may be observed in the proportionate length of the intestine in the tadpole and frog. There are few forms in which the intestinal tube is not considerably longer than the body; from the consequent folding of the tube within the cœlom, a corresponding complication of the mesentery which suspends the tube occurs.

Increase in length of the whole tube is only one way in which a greater secreting and absorbing surface may be brought about. Frequently this is effected by the mucous membrane alone, which may be elevated into villi, or depressed into follicles, or may be raised into straight or spiral folds of various forms as in the Selachians and Ganoids. Again, blind tubes or cæca may be given off, such as the pyloric appendages of the Teleosts, or the cæca given off by the large intestine in birds and mammals. In different parts of the tract, certain constituents may be specially developed; thus, in the gizzard of the granivorous birds, the muscular coat is locally thickened, while in the glandular stomach in front of it, the hypoblastic cells are chiefly responsible for the increased thickness of the wall.

In many lower vertebrates, the limit between œsophagus and stomach is hardly indicated, but in most higher forms the stomach is not only distinguished by its being dilated, but also by a sudden change in the nature of the lining cells, and by increased complexity of the muscular coat. The gastric glands are tubular in form; their function is the secretion of the gastric juice.

Immediately behind the pyloric valve the small intestine is characterized by the reception of the ducts of two important glands, the liver and pancreas, both of which are developed from this part of the intestinal tract, and are formed, to a large extent, of hypoblastic secreting cells. Of these the liver is the largest, and is further distinguished by its paired development, expressed in the adult by the right and left lobes. Only in some primitive forms do we detect the original tubular disposition of the hepatic cells; as a rule, this is concealed in the course of development. The bile secreted by the cells collects in their interstices, which simultaneously are the roots of the bile ducts, through which the secretion is conducted, either directly or with the intervention of a gall-bladder, into the intestine.

Frequently in close connection with the bile-duct is the pancreatic duct, the ramifications of which terminate in a racemose manner, like the ducts of the salivary glands. A considerable resemblance is to be detected between the pancreas and the salivary glands, not only in the cells, but also in their secretion. In certain fishes the pancreas appears to be absent. When such is the case, its function is performed by smaller glands of similar nature in the intestinal wall, but it is sometimes only apparently absent, as it follows the ramifications of the bile-duct throughout the liver, although its cells and ducts are quite independent of those of that organ.

The large intestine is shorter, as a rule, in the lower than in the higher forms, and has little significance in the absorption of food. It may terminate independently on the surface by a separate anal aperture, or may open into an involuted area of the skin (the cloaca), into which the ducts of the urinary and genital organs also empty.

THE RESPIRATORY ORGANS.

The Gills.

It has been indicated above (p. 15) that all vertebrates have the anterior part of the alimentary canal perforated by visceral clefts, which primitively allow streams of water to flow over the gills formed on their walls. The clefts originate as hollow outgrowths of the alimentary canal, which extend to the skin, which is subsequently perforated. In air-breathing forms the clefts are only present in the embryo, and disappear entirely or undergo a change of function in the adult. They are much more numerous in Amphioxus, and even in the Myzonts, than in the more typical fishes, where they are ordinarily six in number. Of these, the first is called hyomandibular, as it is situated between the mandibular and hyoid arches; the others are generally termed branchial clefts, and are separated from each other by more or less complete partitions bearing the gill-filaments, and strengthened by the branchial arches described above. The partitions referred to are complete in the sharks, where the clefts open independently on the outside by a series of slits, but in the Ganoids and Teleosts the partitions are very rudimentary, the branchial arches carrying little else than the gill-filaments and the vessels and nerves distributed to them. In this way the gill-clefts are extremely wide in the Teleosts, but they are not visible on the sides of the head as in the sharks, for they are concealed by the gill-cover, a fold of skin which projects back from the hyoid arch, and is strengthened by the opercular bones. This gill-cover not only serves to protect the gill-filaments, which would otherwise be exposed, but aids, by its movements, in promoting a stream of fresh water over their surfaces. Each gill-bearing arch, except the first and last, bears two rows of gill-filaments, one of which looks into the pouch or cleft in front, the other into that behind it, but there is hardly any trace of a partition separating the rows in the Teleosts, so that the two series of filaments count as one gill.

The hyomandibular cleft loses its respiratory function very early in the vertebrate series, and either disappears or persists with an altered function, as was described under the auditory apparatus. It is present, more or less completely, in many sharks and Ganoids, and frequently opens to the outside by an aperture behind the eye, — the spiracle. From this opening, the cleft is sometimes known as the spiracular cleft, and a rudimentary gill situated on its anterior wall as the spiracular gill; but this gill is not functional, — it receives only already aërated blood, and is therefore known as a false gill or pseudobranch. The hyoid arch carries only one row of gill filaments (the posterior) which help in the aëration of the blood in Sharks and some Ganoids, but receive only blood already aërated in the Teleosts, and consequently constitute a hyoid or opercular pseudobranch.

Two very different classes of structures are known as external gills. The embryos of many Selachians possess very long filaments, which extend out from the pouches to the outside (Fig. 16) and apparently have a nutritive function, their epithelial covering serving to absorb yolk particles; but the mud-puppy (*Necturus*) and similar perennibranchiate Amphibia possess permanent, other forms only temporary, external gills,

which project widely outwards from the branchial arches, and do not come into relation to the clefts separating them.

The Air-Bladder.

Various accessory respiratory organs occur in fishes which are exposed to peculiar physical conditions, such as the drying up of the rivers or ponds in which they live. These exceptional structures will be described under the genera in question; but almost all fish-like forms, with the exception of the sharks, possess a bladder formed from the anterior part of the alimentary canal, which, as it contains air, and has blood-vessels in its walls, is often of respiratory importance. This air-bladder is generally considered to be homologous with the lungs of higher vertebrates, having come first partially, and then entirely, into use instead of the gills. We shall consider this homology after having discussed the form and function of the bladder as it ordinarily occurs.

In the Ganoids and more primitive Teleosts (Physostomi) the air-bladder communicates with the intestine, generally in front of the stomach, and either by a slit, as in the Ganoids, or by a duct. On the other hand it is completely closed from the intestine in the less primitive Teleosts (Physoclysti). Whether provided with an air-duct or not, it lies between the intestine and the vertebral column, and when it opens into the intestine does so, with but few exceptions, on the dorsal wall. Conformably with its development it presents the same coats as the intestine, viz., a connective tissue coat, a muscular coat, a submucous coat containing vessels, and a mucous coat. The last rarely presents any glands, and may often be formed of a single layer of flat epithelium; so, also, the submucous coat may contain very few vessels, and thus be of no importance for respiratory purposes. But in certain instances the vessels are more numerous, and may be extremely abundant, as in the bow-fin and gar-pike (*Amia* and *Lepidosteus*). Indeed, in the former genus, almost all the blood sent through the last pair of gill-arches is diverted into the walls of the air-bladder; the same is the case in the African Ganoid *Polypterus*, where the air-bladder opens on the ventral wall of the œsophagus, and we have only to conceive the series of gill-filaments on the gill-arches to be absent, and the blood to pass through the corresponding aortic arches without being aërated, to have the air-bladder supplied with blood in exactly the same way as are the lungs in the air-breathing vertebrates.

In many forms destitute of an air-duct, the capillary vessels are not distributed regularly over the whole surface of the bladder, but form a dense meshwork at one or more spots, known as *retia mirabilia*. These are thought to serve for the absorption or secretion of air, which thus comes from the blood, in the absence of a direct communication with the outside. Even when a duct is present, it is frequently so narrow and tortuous that it is hard to conceive air being taken in through it, although, occasionally, bubbles are, no doubt, ejected by this channel, so that we have to conclude that also, in such cases, the blood vessels are the source of the air contained in the bladder. But where a wide opening exists, as in the Ganoids, it is obvious that the respiratory importance of the bladder may be much greater.

The muscular coat is often undeveloped, but in certain cases it may contain striped fibres, continuous with those of the œsophagus, or it may be functionally replaced by muscles arising from the vertebral column and distributing themselves over the bladder. In many instances, however, the air contained in the bladder does not appear to be controlled by voluntary muscles. Such is apparently the case where the outer

connective tissue coat is very thick, as it frequently is. This coat may become closely attached to parts of the vertebral column, or may itself become ossified in part.

Apart from the respiratory function, which is only important in a few forms, the air-bladder occasionally becomes subservient to the auditory organ, with which it may be connected directly, or with the intervention of certain modified parts of the anterior vertebræ. But its most important function is a hydrostatic one, in virtue of which a fish possessed of an air-bladder is able to alter the amount of the contained air, and, consequently, its own specific gravity, so as to be in equilibrium under varying pressures.

As far as form goes, the air-bladder rarely presents a subdivision into right and left sacs, like the lungs. It is more common to meet with a subdivision into anterior and posterior chambers, an arrangement apparently serving to alter the centre of gravity as occasion requires.

The Lungs.

In discussing the homology of the lungs of the higher vertebrates with the air-bladder of fishes, a difficulty occurs at the outset, viz., that the latter organ is developed from the dorsal wall of the intestinal canal, while the lungs grow out from the ventral wall. Two ways out of this difficulty have been suggested. Either the lungs are not completely homologous with the air-bladder, and are merely similar outgrowths from the same division of the intestinal tract, or they are completely homologous, and one or other organ has shifted its original place of development. That the latter is the true explanation appears to be indicated by the similarity of the blood-supply of the air-bladders in *Amia* and *Polypterus*, taken in conjunction with the diversity in the position of the air-duct. The amphibious Dipnoan fishes lead us from the condition in *Polypterus* to that in the Amphibia proper, while the Teleosts more closely resemble *Amia* in this respect. It has been suggested that the ventral opening is the more primitive position, and that the dorsal position has been secondarily acquired, along with the hydrostatic function.

As far as structure goes, the lungs in many of the lower vertebrates present little advance over the air-bladder as met with in the gar-pike and bow-fin. But as we advance to the higher forms, the tendency is towards greater complexity of the surface, so that, instead of being simply bladder-like, the lining membrane becomes first raised into folds, and eventually the whole organ becomes spongy by the increased number and subdivision of these partitions. The minute chambers bounded by these folds are then known as air-cells, and the whole system of air-cells communicates with the back of the mouth-cavity, or pharynx, by the wind-pipe, or trachea, which represents the air-duct of the Physostomous fishes. It is often the case in the reptiles, that all of the wall of the lung does not become complicated in this manner. Parts remain thin and bladder-like, and this is the condition of affairs which is so exaggerated in the birds, where the thin parts (air-sacs) are often extraordinarily developed, pushing all yielding parts before them, displacing the marrow of the bones, filling up interspaces between the intestines, or forming sacs beneath the skin.

With the complication of the lungs in the higher forms, there go hand in hand certain alterations in the wind-pipe, which are partly of respiratory importance and partly subservient to the production of sound. To the former category belong the cartilaginous rings, which prevent the trachea from collapsing, and which are continued to a greater or less extent into the subdivisions (bronchi) which go to each lung. To the latter series of alterations are traceable the formation of the larynx, the

upper modified part of the wind-pipe, which is the organ of voice in most of the higher vertebrates; and of the syrinx, the vocal organ of the birds. The latter is situated at the bifurcation of the trachea, and consists of vibrating folds of mucous membrane with a more or less developed resonating apparatus, in adaptation to which certain of the tracheal and bronchial cartilages are altered. Such is also essentially the structure of the larynx, where folds of mucous membrane — the vocal cords — are set in motion by the current of air passing between them, and are adjusted by certain muscles attached to altered cartilages, here known as thyroid, cricoid, and arytenoid. The resonating apparatus varies much in different forms; perhaps the most remarkable varieties are the huge vocal sacs of the bull-frog, and those of the howling monkeys. There is always a close connection between the larynx and the hyoid-bone, which is established by means of ligaments.

Thyroid and Thymus Glands.

Locally closely related to the respiratory organs, as well as developmentally connected with this part of the alimentary tract, are two so-called glands (thyroid and thymus), which, however, functionally belong to the vascular system.

These structures are common to all vertebrates, and are formed by modification of the epithelium of the gill-clefts, the former on the ventral, the latter originally on the dorsal aspect. They retain this position in the fishes, but in the air-breathing vertebrates, with the disappearance of the clefts, they are subject to considerable variation in this respect. In man, the thyroid lies at either side of the wind-pipe, the thymus behind the breast-bone. Originally of secretory function (at any rate in the case of the thyroid) these structures have gradually become subservient to the lymph-vascular system, and have thus undergone a change of function. The thyroid persists throughout life in functional activity, while the thymus undergoes degeneration soon after birth.

THE VASCULAR SYSTEM.

Under this heading we have to consider the canals and spaces in which are conducted two of the most important fluid constituents of the body — the blood and the lymph. Both of these constituents are composed of a fluid 'plasma,' containing floating corpuscles, and it is the nature of these which renders the two fluids different. In the blood there are two sorts of corpuscles,— the one laden with a coloring matter known as hæmoglobin, which can combine with oxygen in the respiratory organs and part with it to the tissues; the other destitute of coloring matter, and much less constant in form. It is to the former, or red corpuscles, that the blood owes its color, and this varies with the amount of oxygen present in the corpuscles, that is to say, with the degree of aëration of the blood. The colored corpuscles are nearly constant in size and form for each species; with rare exceptions they are small and of circular outline in the Mammalia, but larger, oval, and nucleated in the other classes.

In accordance with the tendency to change their shape, and consequently to move, the colorless blood cells or leucocytes are frequently spoken of as amœboid or wandering cells. They are identical with the lymph corpuscles, and play a very different part in the economy from the colored elements. Not only do they retain the power of independent locomotion, but they can engulf food-particles, grow, and reproduce themselves by division. Unlike the colored elements, they are not confined to the cavities of the vessels, but can effect a passage through the delicate walls of the finest of

these. They are omnipresent in the body, and are to be found pushing their processes into the spaces which separate the elements of the other tissues. In this way the leucocytes play an important part in the absorption of food from the intestinal canal, as well as in the swallowing up of the products of the waste of the tissues, and in the removal of useless parts. The leucocytes so engaged are contained in the lymphatic vessels, which do not constitute a system of closed tubes like the blood vessels, but communicate with all the chinks and crevices of the tissues, and are further interrupted here and there by the lymphatic glands — masses of a peculiar form of connective tissue (adenoid tissue) which effect important changes in the lymph traversing the irregular spaces contained in them. We shall first consider the blood-vessels, as their constancy affords valuable material for study to the morphologist, but it may be convenient to introduce some general statements as to the development and structure of the vessels of both categories.

All the vessels are formed in that layer (splanchnoplure) of the mesoblast which associates itself with the hypoblast to form the intestine. They are to be regarded as spaces formed between the cells of the mesoblast by the collection of fluids, and, consequently, if they are lined by cells which are disposed like epithelium; these are, nevertheless, of mesoblastic origin. The only other elements met with in the walls of the vessels are of the nature of muscular and connective tissues. In certain tracts of the vascular system the muscular fibres predominate, and they even acquire in the heart a histological character, approaching in differentiation that of the voluntary musculature; but in other tracts the walls are almost entirely formed of connective tissue, which may be largely of that kind known as elastic.

Unlike the lymph vessels, the blood vessels form a system of closed tubes, so that if a large vessel be cut across, and an easily-flowing fluid be injected into one end, it will flow along the whole system without passing through the walls, and escape by the other. The system is formed of central receiving and propelling chambers, constituting the heart, from which arteries are given off to the various parts of the body. These subdivide until extremely fine vessels, the capillaries, result, in which changes in the gaseous and fluid constituents can take place, owing to the extreme delicacy of their walls. From the variously-formed meshes resulting from the union of these capillaries, the blood is drained by comparatively thin-walled veins, all of which converge towards the heart. From what has been said as to the function of the colored blood cells, it is obvious that the vessels must have important relations to the respiratory organs. It is necessary to bear this in mind to understand the singular course of development of the blood vessels in the higher forms, and here, as well as in the case of the other systems, it is desirable to start with a comparatively primitive form. Such a type is furnished by the bow-fin (*Amia*) the heart and great vessels of which are represented in Figs. 42 and 43.

As we have already seen, the heart is situated in a special chamber of the body cavity, — the pericardium (p. 11). The great veins converging towards it generally open into a venous sinus, outside the pericardium, which in its turn has a large aperture into the receiving chamber proper, situated on the dorsal aspect of the heart, and called the atrium. The propelling chamber, or ventricle, lies on the ventral aspect, and projects further caudad than the atrium; it is somewhat pointed behind, and in front is narrowed into a conical projection, round which the ear-like appendages of the atrium (auricles) lap so as to appear on the ventral surface. The walls of the atrium are thin, its cavity is subdivided by a sieve-like partition into a smaller left and larger right cham-

ber, both of which communicate through the single large atrio-ventricular opening with the much thicker-walled ventricle. This opening is provided with valves, so that when the sponge-like ventricle is dilated with blood, and contracts upon its contents, the blood is prevented from passing backwards into the atrium, and is forced on into the slenderer part of the ventricle known as the conus arteriosus. This also contains valves disposed in three rows, which allow the blood to flow only in one direction, namely, forwards into the arterial trunk that lies on the ventral aspect of the gill-arches. Ordinary Teleosts have this arterial trunk dilated into a bulb next the heart, which looks like the conus of the Ganoids and sharks, but is not a part of the ventricle like the latter, and is separated from that chamber by a single row of valves. The blood, driven out of the ventricle, flows forwards along the arterial trunk, whence it is distributed to the gills by a series of afferent branchial arteries (*a*), Fig. 43, which ascend the gill-arches, and break up into the capillary network of the gill-filaments. There the blood is aërated, and is then collected into an efferent artery (*e*), which begins low down on the arch, but gradually widens as it ascends, and receives more and more of the aërated blood. Having arrived at the top of the arches, the efferent arteries generally unite in a great arterial trunk, the dorsal aorta, which lies immediately beneath the vertebral column, and gives off arteries at intervals to the various parts of the body. Much difference is to be observed throughout the fishes, both in the mode of the origin of the afferent arteries and in the union of the efferent arteries into the dorsal aorta. A closer inspection of the condition in *Amia* will enable us to proceed towards that in the higher vertebrates. Four pairs of afferent and efferent arteries are present. From the foremost of the latter are continued forwards carotid trunks for the supply of the head; the rest of the blood of the first pair, with the whole of that of the second, flowing into the dorsal aorta. Little of the blood from the third pair of efferent arteries can reach the aorta, for they unite into a vessel (cœliaco-mesenteric) which supplies the viscera. Finally the blood in the fourth pair is distributed entirely to the air bladder.

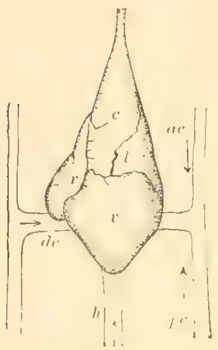


Fig. 42. Heart of *Amia* from below; *ac*, anterior, *pc*, posterior cardinal veins, *dc*, ductus Cuvieri; *h*, hepatic vein; *c*, conus arteriosus; *r*, right, *l*, left auricle; *v*, ventricle.

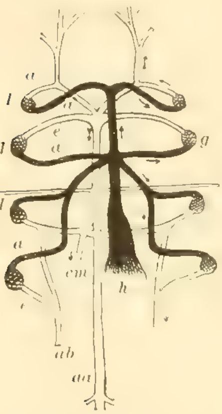


Fig. 43.—Diagram of circulation in *Amia* seen from below; *a*, afferent, and *e*, efferent gill arteries; *aa*, abdominal aorta; *ab*, artery to air-bladder; *c*, carotid; *cm*, cœliaco-mesenteric; *g*, gill-capillaries; *I* to *IV*, gill arches. The unaërated blood is represented by black, the aërated, by white vessels.

The aërated blood distributed in this way is soon converted into venous blood by contact with the tissues, and is then carried towards the heart through the veins. That from the head is poured into the venous sinus through the anterior cardinal or jugular veins; that from the trunk, in part through the posterior cardinal veins. Part of the blood from the trunk, however, passes through the kidneys, and is collected in a single median stem, the inferior vena cava, which joins the hepatic vein from the liver before entering the venous sinus. Just as some of the venous blood from the trunk passes through the kidneys, so the venous blood from the intestines passes through the liver on its way to the heart. It is conveyed into the latter organ by the portal vein, which breaks up into a capillary net-work, allowing the blood to be acted

upon and altered by the hepatic cells, before it is drained off by the branches of the hepatic vein.

We have now to consider the changes which would take place when a fish began to use its air-bladder, in addition to its gills, for respiratory purposes. *Amia* is able to live out of water for some considerable time, undoubtedly because it can change the air in its air-bladder, and thus aërate the large quantity of blood distributed to its walls. Although the blood so aërated is mixed with the unaërated blood returning to the heart from the rest of the body, it is obvious that a sufficient change is taking place as long as the blood flows freely through the third and fourth gill-arches. Such a free circulation in the gills is dependent on their being kept moist. While the fish is in water it is unlikely that the air is changed in the air-bladder so frequently, but it is obvious, nevertheless, that the blood returned from the air-bladder must be richer in oxygen than that which has only been through the gills.

Now in the Dipnoans, which possess a very similar disposition of the vessels, an arrangement exists whereby the purer blood from the air-bladder is kept separate from the blood returning from the rest of the body, and is sent through the more anterior gills, so that the head receives better aërated blood than does the rest of the body. It is to be understood that neither in Dipnoans nor in *Amia* are the two methods of respiration equally active simultaneously, but rather that they alternate in accordance with the requirements of the surroundings.

The arrangement referred to above consists in a subdivision of the atrium into a right and left auricle, and of the conus arteriosus into a right and left passage, the latter carrying the purer blood from the left auricle to the anterior gills. This arrangement, which is not entirely absent in *Amia*, is the first step towards a complete separation of the circulation in the lungs from that in the rest of the body, as in birds and mammals. Every conceivable condition intermediate between that in the Dipnoans and that in the mammals is to be found either in the embryos or the adults of the amphibians and reptiles. If we compare the heart and great vessels of a lizard with those of *Amia*, we shall at once be able to trace the homologous parts.

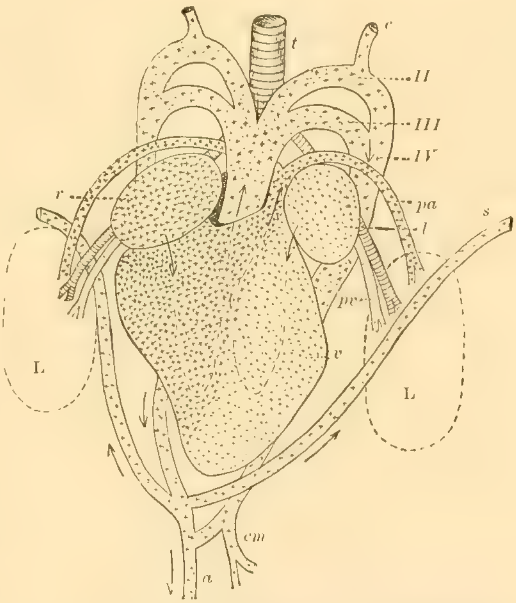


FIG. 44.—Heart of lizard from beneath; the aërated blood indicated by dots, the unaërated by crosses; *a*, abdominal or descending aorta; *c*, carotid artery; *l*, left auricle; *L*, lungs; *pa*, pulmonary artery; *pv*, pulmonary vein; *r*, right auricle; *s*, subclavian artery; *t*, trachea; *v*, ventricle; *II*, *III*, *IV*, remnants of branchial arches.

With the change from an aquatic to a terrestrial life, the gill-filaments disappear, and also the respiratory net-work in these, except where a functionless net-work, or *rete mirabile*, indicates their former position. Generally, the afferent and efferent branchial arteries of each gill are represented by a continuous aortic arch, uninterrupted by any net-work. Five pairs of these aortic arches are present in the embryos of all higher forms, the second of which corresponds to the trunk vessels of the first

pair of gills in the adult *Amia*. They partly disappear with development, and are partly converted into the great vessels proceeding from the heart; this conversion taking place in all in a fundamentally similar manner, although with numerous minor modifications. Fig. 44 will serve to indicate the mode of the conversion of these in the lizard. Here the atrium is completely subdivided into right and left auricles; the former receiving the blood from the body, the latter that from the lungs. Both open into the ventricle, which is partially subdivided in such a way that only venous blood is sent through the fifth pair of aortic arches (pulmonary arteries) into the lungs, while mixed blood is sent to the body through the third and fourth pairs of arches. The first and second pairs present in the embryo are unrepresented in the adult.

It is easy to proceed now to the last term in the evolution of the vascular system, that which obtains in the mammals. Here the ventricle is completely subdivided into right and left chambers, the former of which propels the venous blood into the lungs through the pulmonary artery, which is derived from the fifth aortic arch of the left side only, while the latter propels the aërated blood received from the lungs by the left auricle into the systemic aorta, the representative of the left fourth aortic arch of the embryo. The two foremost pairs of aortic arches disappear without leaving any trace, and the third is merely represented by parts of the carotid vessels destined for the supply of the head. In the mammals it is obvious that the aërated arterial, and the unaërated venous, blood, are thus kept unmixed, a condition which is reached also in the birds, and almost perfectly in the crocodiles.

The Lymph-Vascular System.

We have already touched upon the nature of the lymph, and on the roots of the vessels in which it flows: a few words will suffice to indicate the disposition of the vessels themselves. Like the veins, they are thin walled, and course towards the heart, but the principal stem in which they terminate generally opens into one of the great veins, not into the heart itself. As a rule, the larger lymph vessels are to be found side by side with the blood vessels, although the smaller branches unite much more freely with each other than is the case with the smaller arteries and veins. Many of the lower vertebrates have lymph hearts, which assist in the propulsion of the contents towards the heart; but these do not occur in the mammals. The special way in which the masses of adenoid tissue, referred to above, are interpolated in the course of the lymph vessels, is very different in different forms, but the lower vertebrates have much less distinct and differentiated lymphatic glands than the higher forms. In the latter, we distinguish as mesenteric glands those which are interpolated in the course of the absorbent lymphatic vessels distributed to the intestinal walls. Although they can hardly be said to be differentiated in the lower forms, yet certain masses of the same sort of tissue have taken on special functions, apparently in connection with the elaboration of the blood, so that they are often called blood-glands. The most constant as well as the largest of these is the spleen, but the thyroid and thymus, to which reference has already been made, evidently belong to the same category. It is interesting to note that this sort of adenoid tissue may invade organs of originally very different function, and convert them into lymphoid organs. The thyroid and thymus furnish instances of this, while, in the Teleosts, the foremost part of the kidney may become converted into a lymphoid organ, similar in appearance to, and as bulky as, the spleen. In connection with the lymph vascular system, it is proper to mention that the cœlom and its various compartments are, in

reality, large lymph spaces, for minute lymph vessels open freely into them, so that a fluid injected into the cœlom is readily taken up by the small communicating lymphatics.

In many lower vertebrates the cœlom communicates with the outside by abdominal pores. These are not always homologous, although they may perform, in certain instances, the same function — the discharge of the sexual products. Although the nature of these structures is by no means clear, it appears that they are, in certain cases, remnants of the ducts of the sexual organs, and thus more properly referable to the urogenital system, which we shall now briefly consider.

THE UROGENITAL SYSTEM.

In many Invertebrata, as well as in Vertebrata, a close connection is observable between the urinary and the reproductive organs. This is notable in the Annelids, where each chamber of the cœlom communicates with the outer medium by means of a more or less coiled tube. These segmental ducts are sometimes enlarged in special regions, so as to carry off the reproductive elements shed into the cœlom, thus serving a double purpose. Those anatomists who believe that the ancestral vertebrates were annelid-like base their arguments largely on the very similar conditions which exist in vertebrates, for in these the primitive excretory organs are likewise segmentally disposed, and parts derived from them serve for the outward conveyance of the sexual products.

The essential structure of the kidney, in all vertebrates, is a system of coiled tubules lined with glandular epithelium, derived from the lining membrane of the cœlom, with which, in the lower forms, the end of the tubule may communicate. Into each tubule there grows a tuft of finely divided blood-vessels, which interrupt the flow of the blood in such a way as to cause part of its watery constituents to soak through into the cavity of the tubule. Furthermore, the walls of the tubules are richly provided with capillaries, so that the glandular cells can select from the passing blood the effete matters which must be removed from circulation.

In the fishes and Amphibia the kidney is usually divisible into two parts, — a pro- and a meso-nephros, — in both of which a segmental arrangement is detectable; but in the higher forms, a third part — the permanent kidney or metanephros — is developed, in which the tubes never show a segmental disposition. The duct of the metanephros, or ureter, never serves for any other purpose than carrying off the urine, but such is not the case with the segmental parts of the kidney. In connection with them are formed two ducts, — the Müllerian and the Wolffian, — the former of which is fully developed in the females of all Vertebrates as the oviducts, but is only rudimentarily present in the male. The latter has a more complicated fate; in fishes and Amphibia, the Wolffian duct serves in the female sex merely as a urinary duct, while in the male both the urine and the male reproductive elements are conveyed outwards by it. In the higher forms, the Wolffian duct is barely represented in the female sex, while it serves only as a sperm duct or vas deferens in the male.

A considerable difference exists between the male and female sexual glands as to their relationships to these ducts. The ovaries generally shed the ova into the cœlom, whence they are collected by the open mouths of the Müllerian ducts, but the testes become more intimately united with the Wolffian duct by the intervention of certain altered urinary tubules (the epididymis), so that the sperm-cells never fall into the cœlom.

In many forms of reptiles, and in birds, the oviducts are not symmetrically developed, one only becoming functionally active; but in mammals both oviducts are developed, and generally fuse in their lower parts into a median chamber — the uterus, in which the young are nourished by a placenta for a longer or shorter time. Much difference prevails as to the mode of opening of the urogenital ducts, and their relationship to the intestine. While they open independently of the intestine, as a rule, in fishes, such is not the case in Amphibia, reptiles, and birds, where all open into a common cloaca, which in its turn has a single aperture to the outside. In most mammals, again, the urogenital ducts open in front of the anus into a urogenital sinus, in connection with which are developed the external reproductive organs.

In place of opening directly to the outside, the urinary ducts may first expand into a bladder, serving as a reservoir for the urine, or there may be an 'allantoic' bladder, developed in a different way, although discharging the same function, with which the urinary ducts have no direct connection except in the higher mammals.

The mention of this allantoic bladder renders it desirable to explain a feature of the development of the higher vertebrates, which was not alluded to at the beginning of this sketch. In all reptiles, birds, and mammals, a protecting sac is early formed around the embryo, known as the amniotic sac, and consequently these forms have been designated Amniota, in contradistinction to the Anamnia (that is, the fishes and Amphibia), which are destitute of it. The allantois is another fœtal membrane, which is, however, developed from the intestine, and, being richly supplied with vessels, serves for the respiration of the embryo, either by approaching the surface of the egg in oviparous forms, or by coming intimately into contact with the blood vessels of the uterus, as in the placental mammals. While the amnion is entirely discarded at birth, this is only true of a part of the allantois, the remainder of which is chiefly converted into the urinary bladder.

In the foregoing sketch it has been thought desirable to devote most space and illustration to the discussion of those organs which are most easily studied by the beginner in comparative anatomy, while enough has been said with regard to the other systems of organs to enable the reader to put in their proper place isolated structural details which he may meet with in the following pages.

R. Ramsay Wright.

CLASS I.—TUNICATA.

Nowhere in the whole vertebrate alliance is there as good an illustration of degeneracy as in the group known as Tunicates or Ascidians. Many of the species start in life with the promise of reaching a point high in the scale, but after a while they turn around, and, as one might say, pursue a downward course, which results in an adult which displays but few resemblances to the other vertebrates. Indeed, so different do they seem, that the fact that they belong here was not suspected until little over a decade ago. Before that time, ever since the days of Cuvier, they were almost universally regarded as molluscs, and many facts were adduced to show that they belonged near the acephals. In the later years, when the facts of development began to be known, this association was looked upon with suspicion, and by some they were placed for a short time among the worms. Anyone who has watched the phases of their development cannot help believing that they belong here, the lowest of the vertebrate series.

Before treating of the development, let us consider the structure of the adult, taking as our type one of the common, simple forms, like *Ascidia* or *Cynthia*, and illustrating the facts of anatomy by means of a diagrammic figure. The tunicates derive their name from the fact that the whole body is invested with a tough envelope or 'tunic.' This tunic or test may be either gelatinous, cartilaginous, or leathery. In some forms it is perfectly transparent, in others it is translucent, allowing enough light to pass to show the colors of the viscera; while in still others it is opaque and variously colored. The tunic is everywhere free from the body proper, except in the region of the two openings now to be mentioned. One of these openings occupies a more or less central position, while the other is usually at one side, or may even be placed at the opposite end of the body. On placing one of the ascidians in a glass dish, and sprinkling a little carmine or indigo into the water, we can study some of the functions of the animal. As soon as the disturbance is over, the animals will open the two apertures referred to, when it will be seen that each is surrounded with blunt lobes, the number of which varies with the species. As soon as they are opened, a stream of water will be seen to rush into the central opening, carrying with it the carmine, and a moment later a reddish cloud will be ejected from the other aperture. From this we learn that the water passes through the body. Why it does so is to be our next inquiry. On cutting the animal open we find that the water, after passing through the first-mentioned opening (which may be called the mouth) enters a spacious chamber, the walls of which are made up of fine meshes, the whole appearing like lattice-work. Taking out a bit of this network and examining it under a

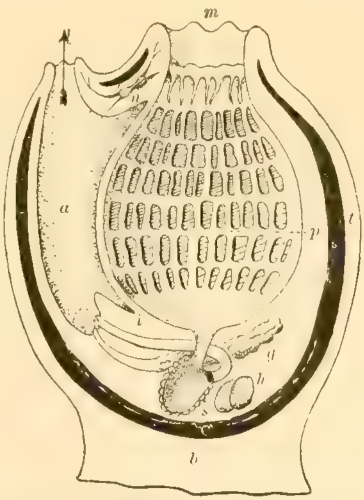


FIG. 45.—Diagram of an ascidian; *a*, atrial chamber; *b*, base; *c*, cavity of tunic; *g*, genital organs; *h*, heart; *i*, intestine; *m*, mouth; *n*, nerve; *p*, branchial sac; *s*, stomach; *t*, tunic.

microscope, we find that the edges of the meshes are covered with myriads of minute hairs, or cilia, which are in constant motion, forcing the water through the holes. Of course the supply has to be made good, and hence more water flows in through the mouth. This large cavity is known as the branchial or pharyngeal chamber, and would seem to be homologous with that of the fishes. On one side of this sac (opposite to the nervous ganglion), between the mouth and the bottom of the chamber, arise two folds with ciliated surfaces, which pass forward and form a closed ring near the mouth, which beneath the ganglion gives rise to a small process extending into the branchial chamber. The other, ventral portion of this organ has glandular walls, and is known as the endostyle. In the living animal, when viewed from the side, it appears like a tube. Usually special gills are developed as folds of the wall of the branchial chamber.

The water, after passing through the branchial network, is received into narrow passages and conducted to a larger portion — the cloacal or atrial chamber. The general relations can be seen from our diagram, illustrating a vertical and horizontal section. From the atrial chamber the water flows out into the external world.

Now we can readily see how in the older works naturalists were misled in regard to the affinities of the tunicates. They regarded the tunic as the equivalent of the mantle of the molluscs (see Vol. I.), while the incurrent and excurrent openings corresponded to the siphons. In one genus, *Chevreulius*, the resemblance was even stronger, for there the tunic is in two parts, united by a hinge line, and closed by an adductor muscle. How and why these views were totally erroneous will be seen when we come to consider the development of these animals.

At the bottom of the pharyngeal sac is the narrow œsophagus, surrounded with cilia which force a current down into the digestive tract. The branchial meshes serve as a strainer for the water, and the larger particles which it contains fall down until they are within reach of the current going down the œsophagus. After passing through the throat, they come to the stomach, where digestion takes place, and then the rejectamenta are carried out through the intestine and poured into the bottom of the atrial cavity.

The heart lies on the ventral side of the stomach, and is surrounded by a well-developed pericardium. The most remarkable fact connected with the circulation is that the heart, after beating a short time, forcing the blood through the vessels, will suddenly stop for a moment and then resume its beats; but, strange to say, after the stoppage, the direction of the circulation is reversed, the blood taking an exactly opposite course from that formerly pursued. This most exceptional condition was first seen in the transparent *Salpa*, but it may be witnessed in the young of most genera. We have already referred to the branchial chamber. The walls of this chamber, besides acting as a strainer, are also respiratory organs. The meshes of which they are composed are in reality tubes through which the blood circulates, and thus is brought in contact with a constantly renewed supply of fresh water.

The nervous system in the adults of all except the Copelatæ seems to be reduced to a single ganglion placed near the mouth, and thus indicating the dorsal side. In forms like *Cynthia* it holds the same relative position with regard to the mouth, but by the doubling of the body (to be explained farther on) it is also brought near the atrial aperture, where it is shown in our first diagram.

The sexes are combined in the same individual, though usually the products ripen at different times. As a rule, the earlier stages of the embryo are passed inside the

cloacal chamber, though in some the development occurs outside the body. As a type of the development we will consider that of one of the solitary forms, leaving the many curious modifications to be noticed in connection with the species in which they occur. This will be best, since these forms show the relationship to the other vertebrates in the clearest manner.

The egg undergoes a total segmentation and a regular gastrulation. Soon a tail appears, and under the microscope the young embryo, which now begins its free life, appears much like the tadpole of the frog. It has a large oval body and a long tail which lashes about, forcing the animal forward with a wriggling motion. Nor is the resemblance superficial; it pervades every part of the structure, as may be seen from the adjacent diagram. The mouth is nearly terminal and communicates with a gill chamber provided with gill clefts. At the posterior end of the gill chamber begins the alimentary tract, which pursues a convoluted course to the vent. Just above the intestine are the rudimentary urogenital organs, which empty either into the rectum or just behind the vent. In the tail, but not extending to any distance into the body, is an axial cylinder — the notochord, which here, as in all other vertebrates, arises from the hypoblast; and above it is the spinal cord (epiblastic in origin), which extends forward to the brain, above the gill chamber. Besides, the animal is provided with organs of sight and hearing. So far the correspondence between the two types is very close, and if we knew nothing about the later stages, one would without doubt predict that the adult tunicate would reach a high point in the scale of vertebrates. These high expectations are never fulfilled; the animal, on the contrary, pursues a retrograde course, resulting in an adult whose relationship to the other vertebrates would never have been suspected had the embryology remained unknown.

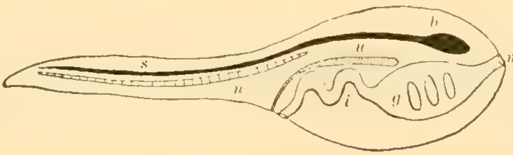


FIG. 46. — Diagram of tadpole-like larva of an ascidian; *b*, brain; *g*, gill chamber; *i*, intestine; *m*, mouth; *n*, notochord; *s*, neural cord; *u*, urogenital system.

After the stage described, this retrograde development begins. From various parts of the body, lobes grow out, armed on their extremities with sucking discs. These soon come in contact with some sub-aquatic object and adhere to it. Then the notochord breaks down, the spinal cord is absorbed, and then the tail follows suit, the intestine twists around, and the cloaca is formed, the result being much like the diagram near the head of this section. In forms like *Appendicularia*, this degeneration does not proceed so far; the tail, with its notochord and neural cord, persisting through life.

The tunicates, without exception, are all marine. Some are attached, and others float or swim freely through the water. They feed upon diatoms, small algæ, Infusoria, and minute crustaceans. Their stomachs usually prove rich collecting grounds for the student of the lower forms of life. I have examined them when they were almost entirely filled with the curious cilio-flagellate protozoan, *Ceratium tripos*, while at other times they have contained large numbers of Radiolaria. Most of the species are small, only a small number attaining a length of a few inches. Many of them are highly phosphorescent, especially the transparent pelagic forms. Owing to the entire absence of any hard tissues, fossil tunicates are unknown.

Sub-Class I. — Tethyodea.

Most of the members of this group are attached in the adult condition, though they pass through a stage in their development when they are free-swimming and tadpole-shaped. One of the most important features common to all is, that in the course of their metamorphosis the body is so folded that the mouth and atrial apertures are brought close to each other, and are not placed at opposite ends of the body.

Many of the group are solitary; that is, during the whole of their life each individual remains distinct and separate from all others. Next come the so-called social ascidians, in which the original parent sends off buds which develop into new individuals, each with its own organs, but still connected to the parent. In the last type, the compound ascidians, the condition is variously complicated. The original individual gives rise to buds which develop into new zooids; but these, instead of being distinct, as in the social forms, become united into one mass with more or fewer of the organs in common. We shall recur to these again.

Order I. — COPELATÆ.

In this, the lowest of the orders of tunicates, features characteristic of the larvæ of other groups are retained in the adult. The species are all minute, free-swimming animals, which in the course of their development never pass beyond the tadpole stage. In the tail, the notochord and neural cord persist through life, the latter with ganglionic enlargements at regular intervals, which is accompanied by a segmentation of the mesoblast. Only a single family, Appendicularidæ, is recognized, and the genera are few. *Oikopleura* (or *Appendicularia*) is a genus common on the surface of the seas far from land, both in the tropics and in more temperate regions. Two species have been noticed by Mr. A. Agassiz on the southern shore of New England, but they have not yet been described.

Among the other peculiarities of these animals we may mention that a cloaca is not formed, the intestine communicating directly with the water, and only two gill slits are present. Some of the species form a transparent gelatinous protective envelope, known as the test or house. This is secreted very rapidly, and when complete has two anterior apertures, while from the middle arises a spacious chamber in which the tail has ample room to vibrate. According to Fol this house is occupied for only a few hours, and then the animal deserts it and forms another.

Placed in this family is a very rudimentary form, called by Fol *Kowalevskia*, after the eminent Russian naturalist. In this genus there is no heart and no endostyle, while the intestine is wanting. The only known species comes from the Mediterranean.

Order II. — MONASCIDIÆ.

The term ascidians is frequently employed as synonymous with tunicates, but it is better restricted to embrace the social and solitary forms, the Ascidiæ Simplices of many authors, and the 'sea squirts' of the language of the shore. The family Ascidiidæ includes the solitary forms, the general structure and development of which was sufficiently elucidated in our general account. This family embraces the largest species of

the group, many of which are found on our shores. Some of the most common forms belong to the genus *Molgula*, and individuals of the various species are found attached to rocks and piles, from half-tide mark down to a depth of several fathoms. They are rather small, a large one reaching a diameter of about half an inch, and are usually a pellucid yellow, allowing the color of the viscera to be indistinctly seen, giving the whole animal a very pretty appearance. Possibly most common of all is *Molgula manhattensis*, which I have found in favorable places in countless myriads. In this species the young undergo a portion of their development in the cloaca, and when the tadpoles hatch they swim out as yellow atoms. They form adhesive processes like those described above, but they cannot use them in becoming attached to rocks and stones, since they are entirely enclosed in a peculiar envelope. This envelope, however, is after a while very adhesive, and if the little tadpole happens to touch any part of himself to a stone or shell he is fastened for life. Thus I have frequently seen them adhere by the tail, while the anterior part was making the most violent struggles to escape. Soon, however, they settle down contentedly, absorb the tail, and in a few weeks assume the adult structure. These young possess considerable vitality, as I have kept them for several weeks without changing the water.

FIG. 47.—*Molgula manhattensis.*

The genus *Eugyra* embraces a number of small spherical species, fond of muddy bottoms, where they live unattached. The embryology of a species of this genus has been studied by Lacaze Duthiers (he calls it *Molgula*), and he finds that it does not have a tadpole larva. The fishermen call some of the species of the genus *Cynthia* by the rather appropriate name 'sea peach;' for they are large and nearly spherical, while the colors, red and yellow, are disposed much as in the familiar fruit. The name 'sea squirt' is also given, from the fact that when drawn to the surface these animals will contract still further if touched, sending streams of water out of both oral and atrial apertures.

FIG. 48.—*Eugyra pillularis.*

The only other genus which we shall mention is *Boltenia*, which embraces the 'sea pears' of the fishermen's terminology. These species are usually yellow or reddish in color, and are supported on long and slender stalks which sometimes attain a length of a foot or more. The body proper is pear-shaped, with the openings on one side. The tunic is tough, wrinkled, and leathery, and the animals are utterly unable to keep themselves clean, but are always covered with numbers of seaweeds, hydroids, and other forms of animal and vegetable life.

The family CLAVELLINIDÆ embraces the social ascidians. In structure each of these is much like the members of the last family, the distinguishing feature being that the first individual formed sends out a bud which grows into a root-like stem, developing another individual at the extremity. This second one repeats the operation, and the result is a rather large colony connected by a common stem. In these buds both entoderm and ectoderm are concerned. The latter is derived, of course, from the outer layer of the body, but the entoderm arises as an outgrowth from the branchial sac. The principal genera are *Clavellina* and *Perophora*.

ORDER III.—SYNASCIDIÆ.

This is one of the groups of compound ascidians, and is frequently termed Ascidiæ Compositæ. In all the species numerous individuals are enveloped in a common

mantle, forming a massive gelatinous and frequently brightly-colored colony attached to some stone, or frond of seaweed. In the different groups the individuals are arranged in a characteristic manner, and the colony increases in size by different modifications of the process of budding. In some the body is short and simple, in others it becomes greatly elongated, and is frequently constricted so that it appears to be composed of two or three segments, to which the names head, thorax, and (third) abdomen are usually applied.

In the Botryllidæ, represented on our coast by *Botryllus gouldii*, the body of the individual zooids shows no sign of segmentation, and in the typical genus they are arranged in a star-like manner around a common cloaca. The general structure of one of the systems or groups of zooids is diagrammatically represented in the accompanying cut, which should be compared with the general figure of a tunicate at the beginning of this article. The central cavity is the common cloaca, into which open the water-tubes coming from the branchial sacs of the various individuals. The arrows show the course of the currents of water. *Botryllus gouldii* is very common on the New England coasts, forming gelatinous masses on eelgrass, algæ, and hydoids, which sometimes attain a width of an inch, and a length of eight or ten. The color is very variable. Our figure represents a small colony of three systems. The larva was at first considered as a composite, but more recent researches show that this is not correct. The larva, on settling down, forms an ascidian, which by budding forms a colony. This budding process is very complicated, some three or four generations of buds being formed before a common cloaca is produced. The larva forms a bud and then dies. This bud in turn develops two others and then disappears; the next generation contains four individuals, and so on. These buds at first have no connection with each other, but eventually they arrange themselves into groups, and take the structure shown in the diagram.

Fig. 49. — Colony of *Botryllus* composed of three systems.

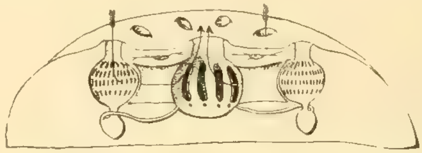


Fig. 50. — Diagram of the structure of *Botryllus*. The arrows show the course of the water passing in through the mouths and out through the central cloaca.

In the Didemnidæ the viscera extend themselves behind the pharyngeal sac, and the body is divided into two portions, dignified by the terms thorax and abdomen. In the next group, the Polyclinidæ, three divisions of the body — thorax, abdomen, and post-abdomen — are present, and each individual is very long. *Amarœcium*, a genus common on our coasts, forms large colonies, some of which reach a foot or more in length. The general color is much like that of boiled salt pork, although more translucent, and the fishermen, who occasionally draw them up on their lines, call them sea-pork. The animals are arranged much as in *Botryllus*, each system having a common cloaca. The process of budding has been studied in some of the species. The larva attaches itself, and develops a solitary zooid, with its three body divisions. Soon the post-abdomen separates from the rest, and divides into several sections, each of which develops into an independent zooid, the parent in the meantime forming a new post-abdomen. Each of the second generation repeats the process, and the result is that the colony increases rapidly in all directions.

Order IV. — LUCIÆ.

In this group are placed a few species of compound ascidians which form thimble-shaped, hollow colonies, the individuals radiating from the axis and being imbedded in a common cartilaginous matrix. The incurrent openings are irregularly disposed on the outer surface, while those for the outgoing stream empty into the hollow of the thimble.

Only a single family, the Pyrosomidæ, is recognized, and of this the principal genus is *Pyrosoma*, which derives its name from its highly developed phosphorescent powers. The members of the genus are found in the warmer seas of the world, where they swim slowly through the water. Their mode of locomotion, if such it may be called, is rather peculiar. Each individual is constantly drawing the water in through the branchial openings on the outside, and pouring it out through the cloaca into the central cavity, and thence back into the sea. This constant streaming forces the whole colony constantly forward in one direction; but there is no adaptation for changing the course. *Pyrosoma* reproduces in two ways, — by eggs and by budding. The eggs hatch and leave the parent, and form the bases of new colonies, which are built up by budding from the zooid produced from the egg.

Pyrosoma, as we have said, is highly phosphorescent, and the larger colonies (*P. giganteum* reaches a length of two or three feet) emit a large amount of light; in fact, the story is told that one naturalist read a description he had written of one of these animals by the light emitted from its body. Each of the individuals has a number of cells near the mouth, the function of which is to produce the light.

Sub-Class II.—Thaliacea.

The members of this division present marked difference from those of the last. All are free-swimming and perfectly transparent, and have the incurrent and excurrent orifices at opposite ends of the body. The branchial cavity is much altered, and the gills take a cylindrical or lamelliform shape, and project into the cavity, dividing it, in *Doliolum*, into two chambers. Expiration is assisted by a number of muscles like hoops, which, by their contraction, force the water out of the cavity, and at the same time the reaction forces the body forward. The alimentary tract forms a small body (called the nucleus) at one side of the branchial cavity.

Order I. — CYCLOMYARIA.

The name used to designate this order, which contains only the family Doliolidæ, has reference to the character of the muscles which surround the body. Each one forms a complete hoop. The body is barrel-shaped, with an opening at either end, and the alimentary tract has not attained the concentrated condition found in the next order. The reproduction is accompanied by an alternation of generations, numerous cases of which are described in the lower invertebrates, but which here and in the next order obtains its only representation in the group of vertebrates. The whole of the history is not known: but essentially it is as follows: We have first a sexual form which produces eggs. From each egg a tadpole-like larva hatches out and develops into an asexual individual. This in turn gives rise to buds which

finally separate from the parent and float freely in the water. Of these buds there are two kinds differing considerably in appearance and origin. One kind develops into the sexual forms with which we began; the fate of the other is unknown. After a longer or shorter time the individuals of *Doliolum* die, and most of the soft parts soon decay; but the outer gelatinous walls last for some time and fulfil a further useful role; for one of the amphipod crustaceans, *Hyperia* by name, uses this dead test as a home, living in it much like a hermit crab in its shell. One species of the genus has been seen on our shores, but it has not yet been described and honored with a Latin name.

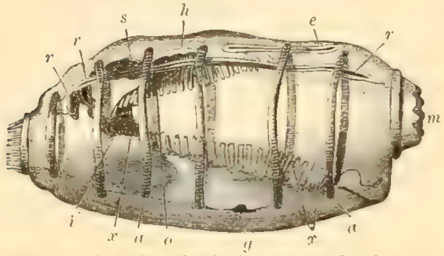


FIG. 51.—*Doliolum denticulatum*: *a*, circular muscles of pharynx; *e*, endostyle; *g*, ganglion; *h*, heart; *i*, intestine; *m*, mouth; *o*, œsophagus; *r*, reproductive organ; *s*, stomach; *x*, branchiæ.

ORDER II.—DESMOMYARIA.

The members of this, the last order of the tunicates, diverges the most widely from the type described in the foregoing pages. The body is nearly cylindrical, sometimes flattened above and below. The muscular bands do not form complete hoops. The generation in these forms is still more complicated than in *Doliolum*, and authorities are still in dispute concerning it. Leaving aside all mooted questions, which are mostly of a technical character, the process seems to be much as follows: Two kind of individuals occur, the solitary and the 'chain zooids,' the latter being united together into long bands, the individuals of which correspond to the links of the chain. From one of the solitary individuals a long process or cord grows out, and then this divides up to form the chain. Each one of the chain zooids contains a single egg, and also the male reproductive organs. The egg ripens before the spermatozoa, becomes impregnated, and undergoes its development inside the parent, to which it is connected by a structure comparable to the placenta of the higher vertebrates. After this young *Salpa* is far along in its developmental history, the male organs ripen and the spermatozoa are cast into the sea to fertilize other eggs. Each egg finally forms a solitary *Salpa*, like the one with which we started. Thus the process is an alternation of generations, and, as expressed by the German poet-naturalist, Chamisso, who first discovered this extraordinary mode of reproduction, "a *Salpa*-mother is not like its daughter, or its own mother, but resembles its sister, its grand-daughter, and its grandmother."

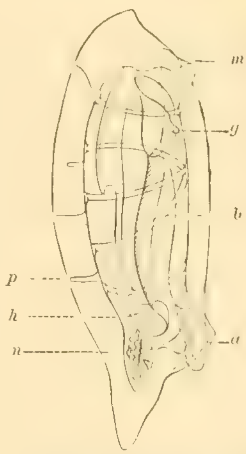


FIG. 52.—*Salpa spinosa*, one individual from a chain; *a*, anus; *b*, gill; *g*, ganglion; *h*, heart; *m*, mouth; *n*, nucleus; *p*, processes by which the various individuals of the chain are connected together.

Usually it is thought that the solitary Salpæ are asexual and that the chains are sexual; but Dr. W. K. Brooks, who has studied their development very profoundly, thinks otherwise. He regards the solitary individual as the female; and says that it places an egg in each of the chain salpæ, while each member of the chain is to be regarded as a male. From this point of view no alternation of generation can occur.

The chain *Salpa*, before the ripening of its spermatozoa, is to be regarded as a nurse. To the writer it seems that these differences, apparently so marked, are in reality reconcilable; and that it is partly a question of definition, and partly due to the fact that the tissues of the individuals of the chain are outgrowths from the solitary form, so that it is difficult to say which should be regarded as the parent of either sexual element.

The individuals of the chain *Salpæ* are variously arranged, being placed with their axis parallel or transverse to the chain, or in some intermediate position. The members of the chain are held together by means of spurs extending from one to another.

On our east coast a single species, *Salpa spinosa*, (often called *S. caboti*), occurs, forming chains a foot in length or even more, each chain containing two rows. The body is perfectly transparent, but is frequently tinged with red or blue. At times they are very abundant, filling the water for miles.

In the tropical seas they are more abundant, and a considerable number of species have been described.

At present, as we have seen, the ascidians are placed at the bottom of the vertebrate series, but among the so-called worms exists a form, *Balanoglossus*, which may belong here, occupying a place below the tunicates. This view receives considerable confirmation from the researches of Mr. Bateson on the species which lives in the North Carolina waters. Unlike the previously known forms, this species does not produce a Tornaria larva, but develops directly into the adult by processes which recall those of Amphioxus, next to be taken up. *Balanoglossus* and its peculiar larva are figured and described in our first volume.

J. S. Kingsley.

CLASS II. — ACRANIA.

"The lowest of the vertebrates," *Branchiostoma*, occurs nearly everywhere in the temperate and torrid regions along the sea coasts, in shoal waters of a couple of fathoms more or less. In the United States it has been found from New York to the Gulf of Mexico. Its shape and size are such that it readily escapes notice, even where very common. A very large specimen might be two inches in length, three sixteenths of an inch in depth, by about one eighth in width, pointed at each end, translucent and iridescent. Resembling a worm, it is easy to overlook or mistake it. Pallas, its discoverer, 1774, called it a mollusc, and put it in the genus *Limax*. Costa rediscovered it in 1834, and, calling it a fish, made it the type of the genus *Branchiostoma*. Yarrell, in 1836, made for it the genus *Amphioxus*, under which name it is best known.

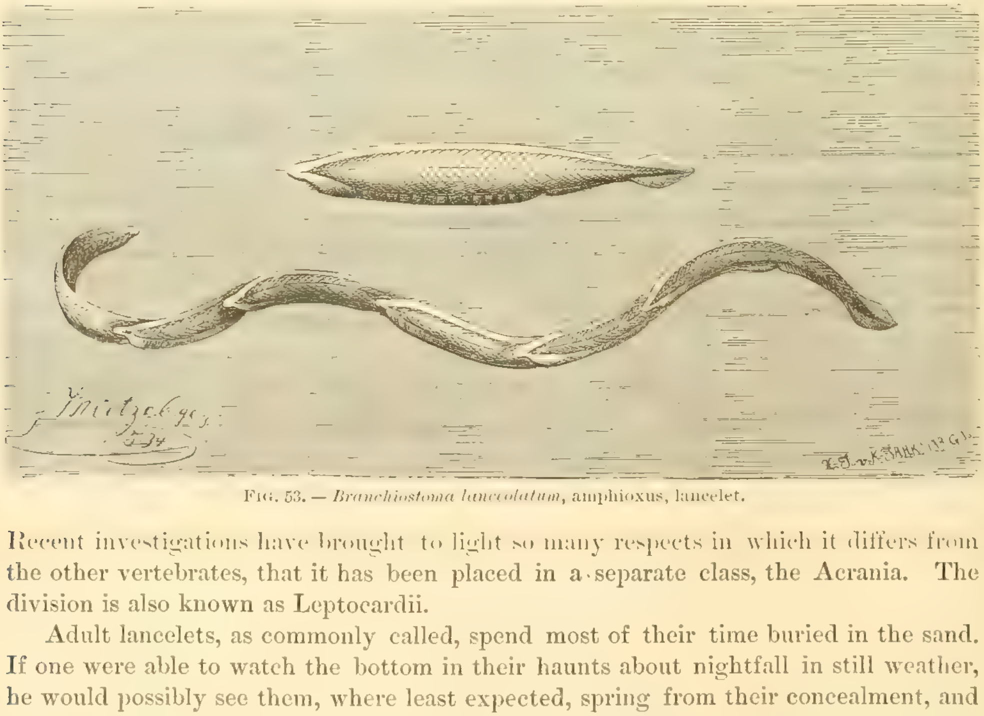


FIG. 53. — *Branchiostoma lanceolatum*, amphioxus, lancelet.

Recent investigations have brought to light so many respects in which it differs from the other vertebrates, that it has been placed in a separate class, the Acrania. The division is also known as Leptocardii.

Adult lancelets, as commonly called, spend most of their time buried in the sand. If one were able to watch the bottom in their haunts about nightfall in still weather, he would possibly see them, where least expected, spring from their concealment, and with a peculiar wiggling motion, in which the head itself moves from side to side, swim toward the surface. After they had wandered about till tired or satisfied, he would see them settle down again, and by quick bendings of the body dig into the sand and throw the cover over them as they retired. Unless an occasional one, resting uneasily, should rush through the sand, or, in a fright, should spring out and frighten all the rest, it would be hard to say just where they had disappeared. A very close inspection, however, would discover little openings here and there; and, looking closer, these would be found to be the tentacle-fringed, open mouths of the little creatures, which, lying on their backs, feed upon the minute organisms, plants, and animals, drawn into the mouth by a current of water that passes out through the gill openings

and the branchial pore. The young are less at home in the sand; probably they do not take to it until nearly adult.

When full grown, the body is of a light flesh color, slender, compressed, and tapering to a point at head or tail. Mouth and vent are a little toward the left side, and each is a little way from the extremity. The former is an elongate oval, surrounded by about twenty-five tentacles; in front of it, around the beak formed by the end of the notochord, along the back, and around the tail from the branchial pore backward, there is a sort of fin or dermal expansion. A third of the length from the end of the tail, in front of the vent, there is an opening or pore into the branchial chamber (atrium or branchium) which allows the escape of the water entering through the gill openings. This chamber lies below the pharynx; when full, it is rounded and transparent; when collapsed it is marked by a translucent fold of its walls along each flank.

On the flanks the muscles bear some resemblance to those of the fishes. Those of the two sides are brought close together toward the 'fin rays,' but are separated over the notochord and viscera. They appear to be arranged in transverse series (about sixty), each band forming an angle directed forward. They are formed of series of more or less regular and overlapping plates, and do not extend quite to the ends of the vertebral column. Besides these, there are transverse and longitudinal abdominal muscles, others about the gills and tentacles, and others around the mouth, vent, pore, and pharyngeal ring.

The alimentary canal is very simple, nearly straight, lined with vibratile cilia, and consists of the mouth, pharynx, œsophagus, stomach, and intestine. A constriction caused by a ring of cartilage called the pharyngeal ring separates the mouth from the pharynx. The latter extends to about the middle of the total length; from it the numerous gill-openings, varying in number with age, let the water pass into the branchial chamber. The œsophagus is short; in it the food that has been strained from the water is compacted into a mass or string, from which the nourishment is ground or squeezed in the stomach. The intestine begins above the pore, at the beginning of the lower fin, and continues to a point a little in front of the end, where the vent opens downward at the side of the fin.

Such a skeleton as that of *Branchiostoma* is hardly worthy the name. What there is of it is composed of the softest of cartilage. There is nothing whatever resembling a skull. A long slender rod, the notochord, pointed at each end, forms the vertebral axis. Outside the rod is a membranous envelope; inside it is a series of thin, flat discs placed side by side. At each side of this axis are the body muscles; below it are the viscera; and above it the neural cord separates it from the fin rays. The pectoral skeleton is united with the dorsal only by ligament. The base of the former is somewhat like a sternum. It supports a ring of cartilages surrounding the mouth, the pharyngeal ring, and the branchial arches which rise like ribs toward the back. Each of the segments composing the mouth ring bears on its front edge a slender rod, the support of a tentacle.

The spinal cord is slender and tapering; it extends from within a short distance of the front end of the notochord to its posterior extremity. Anteriorly, for a little way, it is slightly larger; on its left side there is a slight prominence toward a ciliated pit, supposed to be a nasal fosse. Posteriorly, just above the end of the dorsal cord, there is a short upward bend, ending in a knob. This neural or spinal cord is a mere string, lying upon the notochord, enclosing a narrow canal. Anteriorly the canal is closed, and near the end in front there is a spot of pigment, said by some to be a rudimentary

eye. Pairs of nerves are rooted in the upper part of the sides of the cord, from which they pass out and down to be distributed to the various organs. In number the pairs are the same as the plates or bands of muscles.

Colored blood is not found in the lancelet; the corpuscles are white and few in number. The heart is a bulbous expansion of the principal vein (vena cava), and lies beneath the first branchial arches. The vein is contractile; it extends from the vent to the heart below the alimentary canal, below and above the liver. From each side of the portion beneath the pharynx, vessels carry the blood to the gills; above the latter, on each side, it is received in an artery which carries it back to the œsophagus, where these arteries unite in a single distributing vessel, which continues to the end of the body. From the main heart two small vessels supply the blood for the mouth, and a third that for the pharynx. How the blood is returned from the arterial system to the veins has not yet been satisfactorily determined.

Along each side of the branchial chamber, at the lower edge of the lateral series of muscles, the generative organs are placed. They form two series of about twenty-five little sacs or cases each. Within each of these is developed a quantity of sperm in the male or eggs in the female. When the eggs are near maturity, the sacs are very noticeable in females. On ripening, the contents are set free in the branchium by the breaking up of the walls of the cases, and from this chamber they escape by the branchial pore, or, according to some authors, through the gill openings into the pharynx and out of the mouth. The eggs are fertilized by sperm set free in the water. It is possible that fertilization may take place in the branchium.

The development of the egg is very interesting from a scientific standpoint, and has been followed by Kowalevsky, Hatschek, and, in our own country, by H. J. Rice. Segmentation is not interfered with by food-yolk in the egg. It results in a complete blastosphere (blastula). This blastula has vibratile cilia, and rotates within the enveloping membrane. One side gradually thickens, and, folding inward, becomes the hypoblast, and the embryo, taking on the gastrula form, soon escapes into the water. Here, swimming about by means of the vibratile cilia, it becomes more elongate and cylindrical. The edges of the cup join from in front backwards, leaving a single opening behind. Epiblast and hypoblast approximate along the dorsal axis, and the mesoblast forms as outgrowths of the primitive stomach between them. A medullary plate appears above the notochord, a groove forms upon this, and, later, is converted into a neural canal. After the cavity of the abdomen is formed by the closing in of the sides of the gastrula, the mouth is formed as a narrow slit; as development proceeds, it widens, occupies a more anterior position, and becomes surrounded by the tooth-like tentacles. The gill openings appear behind the mouth one after another. With the appearance of these clefts, folds from the ectoderm grow downward on each flank, and, uniting beneath, form the ventral fin and enclose the branchial chamber in front of it, leaving the pore open. Others of the more prominent changes in the early stages are the forward growth of the liver from beneath the stomach, and the development of the cartilaginous supports of the fins. The very young are quite transparent.

Specimens at hand from the Gulf of Mexico differ considerably from others collected in the Mediterranean. The European species has been named *Branchiostoma lanceolatum*, the American *B. caribæum*. In all six species are known from the whole world according to Dr. Günther, of the British Museum. One form, from Australia, has been regarded as the type of a distinct genus, *Epigionichthys*.

S. Garman.

Class III. — CYCLOSTOMI.

Scarcely larger in number of species than the last class is that which is called either Cyclostomi, Cyclostomata, or Marsipobranchiata; but when the details of structure are considered, its members are at once seen to be worthy of classic rank, exhibiting features which at once place them near the base of the vertebrate series, the lancelet and the tunicates only being below them. Not only their structure and their development proclaim them to be an ancient group, but in the Silurian rocks of Europe and America teeth are found (called conodonts) which with considerable probability are regarded as indicating the existence of lampreys or hag-fishes in the paleozoic seas. Owing to the entire absence of any other hard portions in their anatomy, we cannot hope to find fossils of whose pertinence to this group there can be no doubt.

In shape the Marsipobranchs are much like eels, and in fact the species of *Petromyzon* have among others the common name of lamprey eels. Structurally they differ much from the true eels to be discussed further on. The notochord persists through life, and the true skeletal elements are very feebly developed and never pass beyond a cartilaginous condition. The vertebral column consists of a cartilaginous sheath around the notochord (corresponding to the bodies of the vertebræ in the higher vertebrates), and feebly developed dorsal and ventral arches. The skull also is rudimentary, but serves to protect the comparatively simple brain. No true jaws or paired fins are present. The gills are enclosed in a special pouch (whence the name Marsipobranchii), and the water flows out through one or several external openings. The mouth is nearly circular and is adapted for sucking. In order to hold on more efficiently, the mouth is furnished in the lampreys with numbers of sharp hook-like teeth covered with a horny exterior. The alimentary canal is straight. There is but a single nasal aperture, placed in the median line; and according as its tube terminates blindly or perforates the palate, the class Cyclostomi is divided into two orders.

Order I. — HYPEROARTIA.

In the lampreys the teeth are numerous, and are placed not only on the walls of the mouth, but on the tongue as well. The nasal opening is in the middle of the upper surface of the head, but it does not communicate with the mouth or throat. From the pharynx a single tube on either side leads to the branchial chambers, where the water passes over the gills and then out to the exterior through seven separate holes on each side of the neck. No traces of gill arches are present. A spiral valve is present in the intestine. Two eyes are present. The dorsal fin is usually divided into two parts, one of which may be continuous with or separate from that which terminates the tail.

Some five or six genera and about twenty species of lampreys are known. They frequent the seas and rivers of both the northern and southern temperate zones. The names of the genera *Petromyzon* and *Lampetra* are derived respectively from the Greek and the Latin, and both allude to a habit these animals have of attaching themselves to stones by their suctorial mouth. At other times they attach themselves in

the same way to fishes, and scrape off the flesh with their rasp-like teeth. The portions thus torn off, as well as the blood that flows, forms the larger part of their food. When thus attached they can still breathe, for they draw in the water through the gill slits and then force it out again in the same way.

Lampreys are very differently estimated as food in different places, even within the same country. The ancient Romans prized them highly, and to-day they are held in high esteem in various parts of the Continent and in England, but in Scotland they are despised. In America the same difference appears. In Hartford, Conn., and its vicinity large numbers of the sea lamprey (*P. marinus*) are taken for the table every

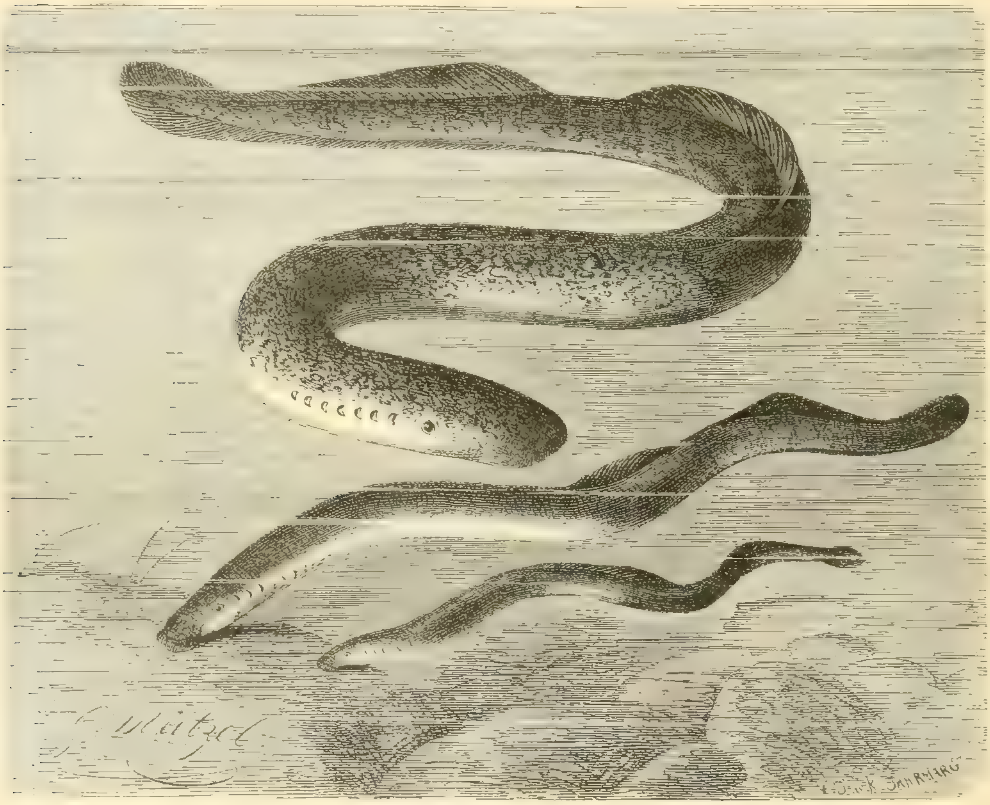


FIG. 54.— *Petromyzon marinas*, sea lamprey (above); *Lampetra fluviatilis*, lampern (middle); *P. branchialis*, pride (below).

spring, but in most other parts of the country they are disregarded. This species attains a length of about three feet, and is the lamprey proper. *L. fluviatilis*, the river lamprey or lampern, is smaller. Still smaller is the pride, or sand-piper, *P. branchialis.*

The lampreys undergo a metamorphosis in their development. The genital products, after ripening in their respective organs, escape into the general body cavity, and then pass out through a genital pore into the sea. Their development has been studied by the late Dr. Calberla of Germany, and Dr. W. B. Scott of Princeton. The earlier stages resemble in many respects those of the Batrachia, but later the embryo takes on its peculiar character and develops into a larval form, long regarded as a

distinct genus, described under the name *Ammocœtes*. The lampreys from the sea go up into fresh water in the spring to lay their eggs, travelling mostly at night. Arrived at the proper places, they build up small piles of stones. In the fall the young return to the sea, but it is almost universally believed that the adults die after fulfilling these sexual functions, though this has not been proved beyond a doubt.

Of the other genera, mention only need be made of *Ichthyomyzon*, from our west coasts, and *Geotria* and *Mordacia*, from Chili and the Australian seas. Of the development of these forms nothing is known; but from the fact that Ammocœte-like forms occur in the same regions, it is probable that they pass through a metamorphosis like the others.

Order II. — HYPEROTRETIA.

Two genera only form the family Myxinidæ, the only one in the order Hyperotretia. These agree in having the nasal aperture communicate with the throat, the mouth small and surrounded with four pairs of barbels, and the number of teeth greatly reduced, there being one on the palate and two rows on the tongue. There may be but a single branchial opening on either side (*Myxine*), or the number may be much greater, and frequently the number varies on the two sides. The intestine is without a spiral valve. But little is known of the genus *Bdellostoma*, which contains but three or four species, all from the Pacific; only one, *B. dombeyi*, reaching the coast of California. In these forms the number of external branchial openings varies from six to eleven or more on each side, each communicating with its own gill pouch. *Myxine* (or *Gastrobranchus*) is somewhat better known, but there are still many points which need investigation in connection with it. On our coast the genus is represented by but a single species, *Myxine glutinosa*, to which the common names of hag-fish and borer have been applied. The second of these names indicates one of the most marked peculiarities of these animals. In their distribution they are much like the codfishes, in which they frequently live as internal parasites for a portion of their life. They also attack other fishes in the same way. They attach themselves to the outside of the body, and like the lampreys they scrape away the flesh with their teeth until finally a hole is made through the walls of the body, and they creep into the abdominal cavity. They have the power of secreting slime in almost incredible quantities, a fact to which they owe their generic and specific names. Kept in confinement for a short time in a small jar of water, they will secrete so much of the mucus as to convert the whole into a mass of jelly. On our coasts they are not very common, though sometimes the fishermen of Eastport and Grand Menan get plenty of them.

Of the development of the hag-fish nothing is known. The eggs are very large in comparison with the size of the animal, and are covered with a horny case which on either end has a cluster of hooked hairs for adhesion. It would appear from the investigations of Prof. F. W. Putnam that their spawning-time at Eastport was during September or October, or even later in the year.

J. S. Kingsley.

Class IV. — ELASMOBRANCHII.

In different works on natural history, three separate names are used for that group of fish-like vertebrates which embraces the sharks and skates. These are Selachii (derived from the Greek word for shark), Chondropterygii (alluding to the cartilaginous nature of the skeleton of the fins), and Elasmobranchii (plate- or blade-like gills). In some respects the group is highly organized, while in others its members stand on a low grade of development. This has resulted in the assignment of the Elasmobranchs to very different positions in systematic arrangement of the vertebrates, according as one set of structures or another was made prominent. It is, however, certain that the sharks and skates have diverged less from the main vertebrate stem than have the Teleosts. The skeleton in the Elasmobranchs is cartilaginous, and the separate elements of the skull are united without sutures; pectoral and ventral fins are present, the former large and well developed; the caudal fin is usually heterocercal, the vertebral column extending into the upper lobe; the mouth is on the lower surface; the gill pouches are usually five in number, but they may be increased to six or seven, the gill slits corresponding; the optic nerves unite in a chiasma; the intestine has a spiral valve, and the conus arteriosus has several rows of valves.

The external surface of the body may be naked, but more usually it is covered with calcified papillæ which in origin and structure are comparable to teeth. Sometimes these ossified papillæ are small and closely set, thus forming shagreen; sometimes they are larger and more widely separated, forming a hardened armor for the body or for certain portions of it. These 'placoid' scales are frequently ornamented with beautiful patterns of sculpture. Sometimes these dermal plates are united to form spines, which usually occur in front of the dorsal fins, but may occasionally be found in other parts of the body. These dermal spines are frequently found in a fossil condition, and are collectively known under the name ichthyodolurites.

The internal skeleton varies much in the extent of its development, and in the relative proportion of its parts. In *Chimæra* a slight calcification, arranged in segments, appears in the sheath of the notochord; and all degrees between this and the condition where the bodies are more or less ossified, and have concave anterior and posterior surfaces, may be found. In the rays, ossification in the anterior end of the vertebral column has converted the whole into a bony mass. Neural and hæmal arches may occur.

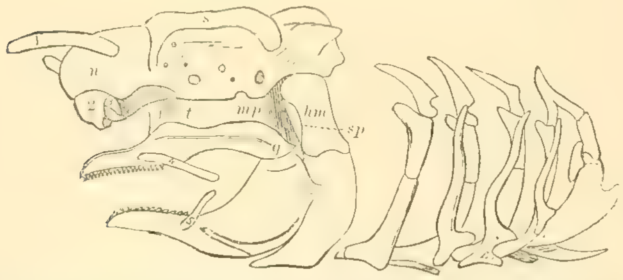


Fig. 55. — Skull and visceral arches of a dog-fish; *hm*, hyomandibular; *m*, lower jaw (Meckel's cartilage with dotted outline); *mp*, metapterygoid ligament; *n*, nasal capsule; *q*, pterygoquadrate; *s*, supraorbital ridge; *sp*, spiracle; *t*, palato-trabecular ligament; 1, 2, 3, 4, 5, labial cartilages.

The skull is cartilaginous and rudimentary, and usually has large membranous fontanelles on its upper surface. In *Chimæra* the palatoquadrate and the suspensorium are united to each other and to the skull, while in the Plagiostomi they are distinct and movably articulated with the skull, the manner of their articulation having recently been made a feature of taxonomic importance.

Neither premaxillaries nor maxillaries are present, but the jaws are composed of the palato-quadrate and the Meckelian cartilage. Frequently large accessory cartilages (labial cartilages) occur. No membrane bones occur in the composition of the skull. There are no opercular bones, and in all, except the Holocephali, the gill-clefts are exposed.

The pectoral arch consists of a cartilage on either side, uniting below in the median line, but never becoming connected with the skull. With this pectoral arch the three basal elements of the pectoral fin (protopterygium, mesopterygium, and metapterygium) articulate, and these bear the radial cartilages which support the fin rays. The pelvic arch is incomplete, and is represented by a pair of cartilages which sometimes unite in the median line and always occupy an abdominal position. The abdominal fins are the smaller. In the males these fins bear appendages, known as 'claspers,' with a semi-ossified skeleton, and so joined that they are capable of motion independently of the fins. The dispute concerning their function (whether they act as claspers, as intromittent organs, or as perforators) has not been decided.

In the teeth of the Elasmobranchs considerable differences may be seen. In *Chimæra*, most rays, and some sharks, they have obtuse crowns, and frequently are so flattened and united that they form a pavement for both jaws, between which crabs and molluscs are readily crushed. In other and the majority of the sharks, the teeth are sharp and conical, and are arranged in rows, the apices pointing backward, so that the prey cannot readily escape when once it passes the opening. These trenchant teeth and their arrangement indicates a rapacious life, and their habits fully accord therewith.

The œsophagus is wide, and communicates with a usually large stomach, but this sometimes can hardly be distinguished from the rest of the alimentary tract. The intestine is short, and just beyond the duodenal portion, which receives the hepatic and pancreatic ducts, the so-called spiral valve begins. This is a contrivance to increase the surface, and consists of an internal fold, the fixed edge of which in most forms follows the wall of the intestine in a spiral manner, but in *Carcharias*, *Galeocerdo*, *Sphryna*, etc., this edge may be straight, and the free edge in this case is rolled up like a scroll, the axis being parallel to that of the intestine. The rectum is short, and opens into a cloaca, which also receives the ducts of the renal and reproductive organs.

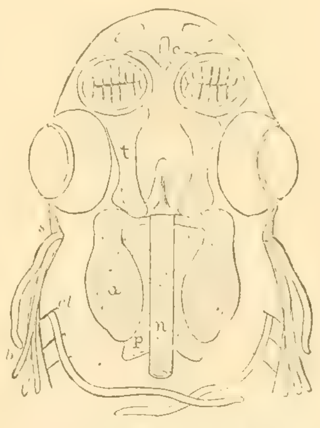


FIG. 56. – Head of embryo dog fish, the upper portions removed, to show the cranial cartilages; *s*, spiracular cleft; *cl*, branchial clefts; *b*, branchial.

The cœlom communicates with the pericardial cavity, and, near the vent, with the exterior, by two abdominal pores. Liver, pancreas, and spleen are present. The heart consists of a single auricle, a single ventricle, and a muscular and rythmically contractile conus arteriosus. On the inner walls of the latter are several rows of semi-lunar valves. In many sharks the first visceral cleft persists through life, and forms a 'spiracle,' an opening extending from the upper outside of the head, in front of the suspensorium, to the cavity of the mouth. From this spiracular cleft, in the early embryonic stage, branchial filaments protrude (Fig. 56).

The brain is much like that of the Teleosts, and is well developed. The optic

nerves coalesce to form a chiasma, as in the higher vertebrates, the olfactory lobes are large, and the olfactory nerves are usually long, dilating into large ganglionic masses at the base of the nasal sacs. The eyes are sometimes provided with a third eyelid—the nictitating membrane—much like that of birds. The labyrinth of the ear (except in Holocephali) is completely enclosed in cartilage. In the Squali the semicircular canals are normal, but in the Raiæ they are circular, and each opens into the vestibule by a separate canal. The ear communicates with the exterior by a canal opening on the top of the head and partially covered by a valvular flap.

The paired male reproductive organs are much like those of the higher vertebrates, and the ovaries are usually paired; in some, however, but a single ovary occurs. The eggs are few in number, and large, a great amount of food yolk being present. The Holocephali, some Raiæ, and a few of the sharks, are oviparous, and lay eggs enclosed in horny capsules, which frequently are prolonged in long horns at the corners. Most of the sharks are viviparous, and, in a few, a rudimentary placenta is formed. In the others, judging from the increase in size of the young during fœtal development, it is probable that some nourishment is received from the mother, though no connection exists between them.

Owing to the ease with which the eggs are procured, their size, and the morphological importance of the Elasmobranchs, the embryology has been extensively studied; the monograph of Balfour easily occupying the first place. The eggs undergo a meroblastic segmentation, and soon a nearly circular blastoderm rests on one side of the yolk. At one edge of this a swelling appears, and, with growth, this increases in length, and forms the first rudiments of the embryo. As development proceeds, this embryo is elevated above the rest of the yolk, which becomes covered by the spreading blastoderm, or the yolk sac, as it is called. In this yolk sac, blood vessels are developed, and the yolk is gradually transformed into blood for the growing young. In the living embryo, the circulation of the blood through this vitelline system can readily be seen. At an early stage the notochord becomes separated from the hypoblast, then the muscle plates (myotomes) appear, the brain becomes divided into its three parts, and the epiblastic involutions for the eyes begin. Then that for the ears occurs, and the visceral clefts are formed. The heart now begins to bend and to beat. Soon the branchial filaments protrude from the visceral clefts, and the continuous median fin is differentiated. During this time the yolk is gradually growing smaller, and the elements of the paired fins are forming. From this stage the development into the adult condition is regular, and the embryo is born or hatched, as the case may be, before the whole of the yolk sac is absorbed.

The Elasmobranchs first appear in rocks of upper Silurian age, and in the carboniferous and Permian rocks their remains are numerous, though they consist chiefly of teeth and ichthyodolurites, the determination of the position of which in a systematic arrangement is almost impossible. In the mesozoic rocks both sharks and skates are found. The older sharks and skates were mostly provided with pavement teeth, indicating a food of molluscs and crustaceans; in the carboniferous, the trenchant teeth began to predominate, indicating a more active and a more predacious nature in their possessors. In the later rocks the fossil teeth are very abundant, especially at certain localities.

The Elasmobranchs are divided into two groups, the Holocephali and the Plagiostomi. The former is the more generalized, and, as we shall see, forms what may be called a connecting link between the various groups of lower vertebrates.

Sub-Class I. — Holocephali.

The Chimæras, though exceedingly bizarre in their appearance, hardly deserve the name applied to the principal genus. Popularly, there is little of interest concerning them, but to the naturalist they present many features to engage the attention. The notochord persists, and the vertebræ are represented by a series of ossified rings in the notochordal sheath. The upper jaw is rudimentary, and firmly united to the skull, while the lower is articulated to the long and slender hyomandibular. The jaws are armed with four plate-like teeth above, and two below. The mouth is small and in-

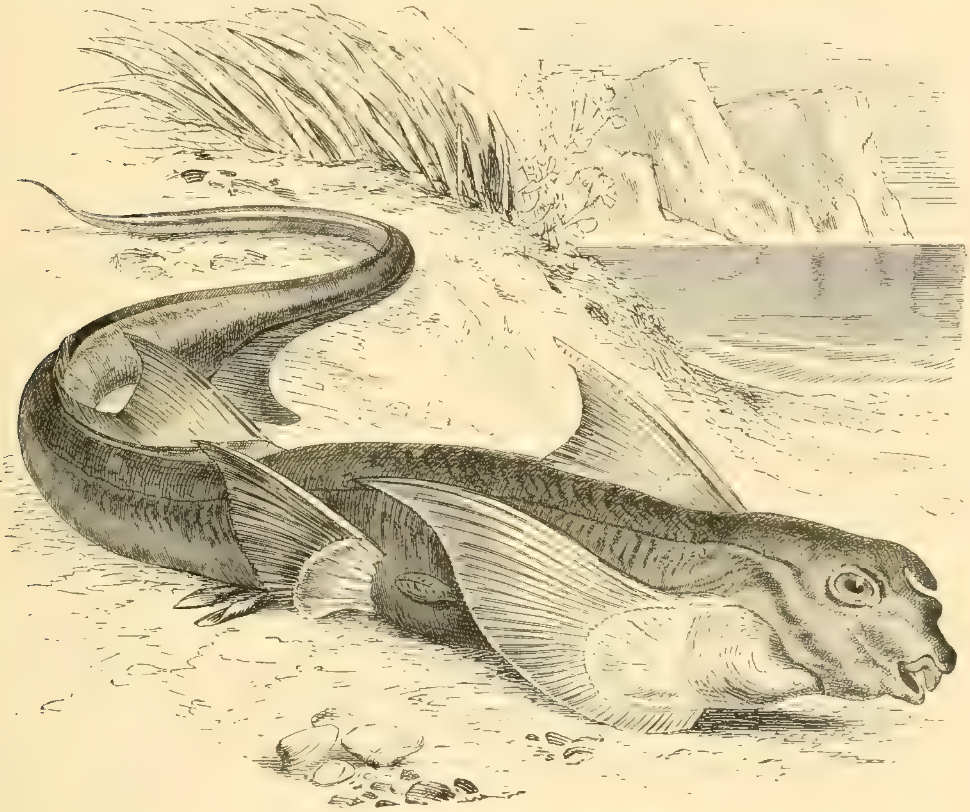


Fig. 57. — *Chimæra monstrosa*, chimæra, spook.

ferior in position; while above the eyes, in the male, is a curious, erectile, stalked appendage, spined at its extremity, of problematic character. The eyes are very large, and are without lids; the skin of the adult is naked, but in the young there are a number of small placoid scales on the back. In the skin, especially that of the head, the neuro-epithelial system is well developed, and the lateral line is present. The gill-clefts are four in number, but they open externally through a single opening which is covered by a fold of the skin, slightly stiffened by cartilage. This rudimentary gill-cover represents the well-developed operculum of the Teleosts or true fishes. No spiracle occurs. The fins, especially the pectorals, are well developed, while 'claspers' occur in connection with the ventral fins of the male. Dr. B. G. Wilder has

studied the brain, and regards it as combining Selachian, Ganoid, and Batrachian characters. Other anatomical features are similarly generalized, and these facts all lead to the conclusion that the Holocephali are the modern representatives of an ancestral type, closely connected with the other Elasmobranchs and with the Ganoids, the Dipnoans, and the Batrachians as well. The eggs are enveloped in horny capsules, but nothing of importance is as yet known of the development.

The earliest remains, which, without doubt, belong to the Holocephali, appear in rocks of jurassic age, but Dr. Newberry thinks the genus *Rhynchodus* from the Devonian of Ohio should be placed here. In many cases it is impossible to decide whether a given fossil belongs to the Holocephali or to the Dipnoans.

The sub-class Holocephali, as represented in the existing seas, is coextensive with the family Chimæridæ. This is represented by two genera; *Chimæra*, mostly from the northern seas, and *Callorhynchus*, from those of the Antarctic region. Of the former, four species are recognized. Best known is *C. monstrosas*, the chimæra, sea-cat, sea-rat, king-fish, spook, etc., of fishermen. This is found mostly in the Arctic seas, but it occurs in the Mediterranean and Japan, and is said to have been taken at the Cape of Good Hope. On our east coast occurs *C. plumbea*, but it is very rare. *C. colliei* of the Pacific is abundant from Monterey north. None of these have any economic value, as the flesh is not good.

The single species of *Callorhynchus* is found in the Antarctic seas, and from this fact derives its specific name *antarcticus*. The most interesting feature connected with it are its peculiar eggs. These are broad and flattened, and reach a length of ten inches, with a width of about three; their shape and their dark-green color make them resemble some of the broad-fronded green algæ. On one side of this capsule are two slits, which allow entrance and exit of water, for respiratory purposes. The eggs are buried in the sand, a little below low-water mark. In the embryos found by Professor T. Jeffrey Parker, the yolk sac was covered with numerous paired blunt projections, and there was practically no yolk stalk.

Sub-Class II. — Plagiostomi.

The sub-class Plagiostomi, or Selachii, as it is variously termed, embraces the sharks and rays, and hence by far the greater portion of Elasmobranchs. Among the characters common to all the members, we may mention the following. The skin is rarely naked, but is usually shagreened or covered with larger bony plates or shields, which sometimes may be developed into spines. The nostrils and the mouth are on the lower surface of the head, and the latter is transverse, and usually armed with numerous teeth. The palato-quadrate (upper jaw) and suspensorium are separate and movably articulated with the skull. The spiracle (first visceral cleft) frequently persists through life; the gill-clefts are usually five in number, but may be six or seven; they are never covered by an operculum. The vertebræ are well developed, and occasionally a diplospondylous condition occurs, each body bearing two arches.

Order I. SQUALI.

In popular estimation sharks have an unenviable name. They are regarded, and justly so, as the most cruel, rapacious, and bloodthirsty of all the inhabitants of the sea. All of the known species, with four exceptions, are carnivorous, and while the smaller species make sad havoc with crabs, molluscs, and schools of fish, the larger ones, when

occasion offers, do not hesitate to attack man. Many are the cases in history and in fiction where sharks have eaten a human being in one or two mouthfuls.

In shape the sharks are long and cylindrical, the body terminating in a sharp snout in front and in a long and flattened tail behind. The mouth is transverse, and usually placed on the lower surface of the head some distance behind the tip of the snout; the gill-clefts vary between five and seven in number and always occupy a lateral position; the edges of the eyelids are free; and the shoulder girdle is incomplete. The differences between the typical forms of sharks and skates are very evident, but a series of intermediate forms intergrade between the Squali and the Raiae, so that almost the only certain external character separating the two is found in the position of the gill slits; lateral in the sharks, ventral in the rays.

Almost all the sharks are marine, though many occasionally follow their prey into the mouths of rivers, where the water is brackish, or even fresh, and one species (*Eulamia nicaraguensis*) occurs in Lake Nicaragua, where it is cut off from the ocean by a river a hundred miles in length. Many species are pelagic, that is, they live in the open seas, following schools of fish or ships for weeks, in the latter case feeding upon the refuse from the cook's galley or on anything else that may fall overboard. Other species are found near the shore, living near the bottom, and only rising to the surface in the pursuit of food. The smaller species often form immense schools, which follow the mackerel or other migratory fishes. The majority of species of sharks are found between the tropics. In the temperate regions they are not so numerous, while the sleeper shark (*Somniosus microcephalus*), the black dog-fish (*Centroscyllium fabricii*) and the basking shark (*Cetorhinus maximus*), enter the Arctic seas. Few of them descend into deep water, only *Centroscymnus cœlolepis* being known from a depth of five hundred fathoms.

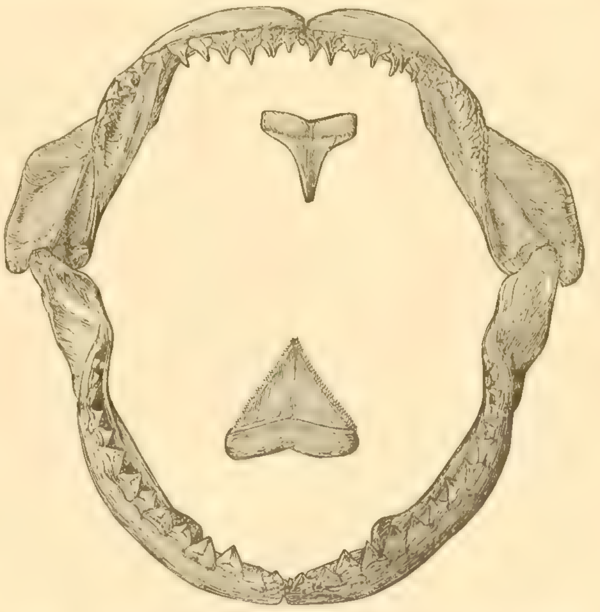


FIG. 58.—Jaws and teeth of the blue shark, *Carcharinus glaucus*; the single teeth are of the natural size.

The teeth of sharks are especially interesting, from the method of replacement of those worn out or torn out. In the majority of sharks the teeth are more or less triangular in outline, and are movably articulated with the jaws. They are arranged in several rows, one behind another, the first or outer row alone being used, while the rest are turned back out of the way. When those of the first row are lost, those of the next row rise up to take their place. In some sharks, however, the teeth develop a pavement much like that characteristic of the rays.

Sharks have but a limited economic value. In the eastern countries many of the smaller species are eaten, while the fins, with their abundant cartilage, form the basis of

the supply of gelatine in China. According to Dr. Gunther "the fins are obtained not exclusively from sharks, but also from rays, and assorted in two kinds; 'white and black.' The white consist exclusively of the dorsal fins, which are on both sides of the same uniform light color, and reputed to yield more gelatine than the other fins. The pectoral, ventral, and anal fins pass under the denomination of black fins; the caudal is not used. One of the principal places where shark-fishing is practised as a profession is Kurrachee. Dr. Buist, writing in 1850, states that there are thirteen large boats, with crews of twelve men each, constantly employed in this pursuit; that the value of the fins sent to the market varies from 15,000 to 18,000 rupees; that one boat will sometimes capture at a draught as many as one hundred sharks of various sizes; and that the total number of sharks captured during the year amounts probably to not less than 40,000. Large quantities are imported from the African coast and the Arabian Gulf, and various ports on the coast of India. In the year 1845–46, 8,770 hundredweight of sharks' fins were exported from Bombay to China."

In our country the economic use of sharks is comparatively slight, though there is a considerable fishing for some species, especially for the dog-fish, *Squalus acanthias*. The livers of this and other species are taken for the oil which they contain. The livers are placed in water, and cooked either by steam or by fire, and then the oil is skimmed off. It is used mostly for adulterating the fish oils used by curriers, and brings, at the time of writing, between forty and fifty cents a gallon. In former times the livers were 'sun-tried'; they were placed in water and allowed to stand in the sun for several days. The quality produced by this method (which is still pursued in Labrador and Newfoundland) is much better than that obtained in the more modern course, but the difference in quantity is considerable. Both quality and quantity vary considerably with the season.

As has been said, the skin of sharks is usually covered by numberless fine and closely set spinous and hardened papillæ, which gives it a rough appearance. These papillæ are so hard that the skin (known as shagreen) was formerly used extensively by cabinet-makers and other wood-workers for the same purposes that sand-paper is now employed.

These economic uses but poorly compensate for the damage these animals do to the fishermen's interests. They not only injure and destroy the nets and seines, but they eat far more fish than are caught; indeed, one can scarcely imagine the extent of their ravages.

The classification of the sharks is in an unsatisfactory condition, that of the fossil forms especially so. Authorities differ as to whether the group Squali should be regarded as an order or have an inferior rank, while the limits and the sequence of the families is also undecided. It may be that the mode of articulation of the palato-quadrate with the skull will give a good basis for taxonomy, but this has not been settled.

The Notidanidæ or Hexanchidæ, embraces less than half a dozen species of tropical or semi-tropical sharks, only one of which is known to visit the coasts of the United States. They have weakly developed vertebræ, which, at least in the caudal region, bear each a pair of arches. The gill sacs are six (*Hexanchus*) or seven (*Heptanchus*) in number; a small spiracle exists; the mouth is armed with teeth differing in character in the two jaws and in different parts of each jaw; the lateral line is well developed, no nictitating membrane exists, and only one dorsal fin occurs. The two genera are, for our purposes, sufficiently characterized above. The common name for these sharks is cow-sharks; one species of which, *Heptanchus indicus*, is distributed

across the whole Pacific, from the Cape of Good Hope to California, and, according to Dr. Jordan, it is not rare at San Francisco. The Notidanidæ attain a length of about fifteen feet.

The recently instituted family, CHLAMYDOSELACHIDÆ, which at present contains but a single species, *Chlamydoselachus anguineus*, deserves mention. Mr. Garman found, in a lot of specimens from Japan, an eel-like shark, six feet long, and less than four inches in diameter. It differed so much from all other known sharks, that a family was necessary, of which the following characters seem the most important. The branchial apertures are six in number, and the opercular fold is broad, and is continuous across the under side of the neck; the mouth is wide, and placed at the anterior end of the head; the eyes are without a nictitating membrane; the single dorsal is placed behind the ventrals, and opposite the anals.

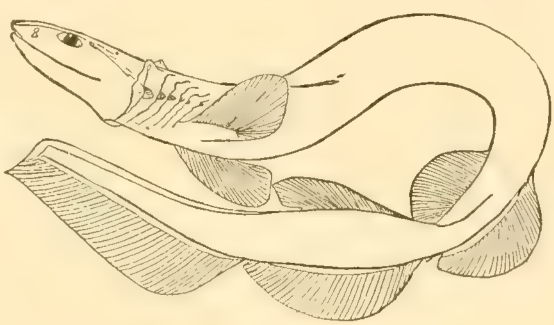


FIG. 59.— *Chlamydoselachus anguineus.*

Mr. Garman has thoroughly studied the internal structure, and finds there differences even more important than those given here, but, as his account is not yet published, the details cannot be given. In his preliminary account, Mr. Garman gives the following remarks, which incidentally indicate the possibility of an allied species on our eastern coasts: —

"Such an animal as that described is likely to unsettle disbelief in what is popularly called the 'sea serpent.' Though it could hardly, on examination, be taken for anything but a shark, its appearance in the forward portion of the body, particularly in the head, brings vividly to mind the triangular heads, deep-cleft mouths, and fierce looks, of many of our most dreaded snakes. In view of the possible discoveries of the future, the fact of the existence of such creatures, so recently undiscovered, certainly calls for a suspension of judgment in regard to the non-existence of that oft-appearing but elusive creature, the serpent-like monster of the oceans.

"Generally, the attitude of ichthyologists in respect to the belief in unknown sea-monsters is much the same; they are inclined to accept it, but are waiting more definite information. A couple of years ago, Professor Baird, in a conversation on the subject, drew a sketch of a strange creature, captured and thrown away by a fisherman on the coast of Maine, which might be readily considered by the ordinary observer as a form of 'the serpent.' It was some twenty-four feet in length, ten inches in diameter, eel-like in shape, possessed of a single dorsal, placed near the head, and had three gill openings. The question was, 'Is it a shark?' In several respects it resembled an eel rather more."

The SCYMNIDÆ (Læmargidæ) embraces about half a dozen large sharks, with no anal fin, and no spines in front of the two dorsals; they have no nictitating membrane; the five gill slits are in front of the pectoral fin; and spiracles are present. Only two species are known on our coasts, and of one of these (*Echinorhinus spinosus*) but a single specimen has been taken here, though it is more common on the coasts of Europe and Africa. This is called the spinous shark, from the fact that the skin bears large round tubercles scattered over the surface, each of which is 'surmounted by

prickles, like those on a bramble, and, like them, leaving a scar when detached.' It is a ground shark, rarely coming to the surface.

The sleeper shark, *Somniosus microcephala*, is rather more common than the species just mentioned, but still it is rare. It is properly an inhabitant of the Arctic regions, and but rarely strays as far south as Cape Cod or the British Isles. Its length varies between eight and twenty feet, and in weight it may reach two tons or more. Its color is a purplish gray, with numerous white spots scattered over its surface. In the Arctic regions it is more common, "and, although it never, or but rarely, attacks man, it is one of the greatest enemies of the whale, which is often found with large pieces bitten out of its tail by this shark. Its voracity is so great, that, according to Scoresby, it is absolutely fearless of man while engaged in feeding on the carcass of a whale, so that it can be pierced through with a spear or knife without being driven away. It is stated to be viviparous, and to produce about four young at a birth." On our coast it often comes near fishing-smacks, and feeds on the offal thrown overboard. Occasionally a specimen is taken on a line and exhibited in the seaport towns. By the fishermen it is known as ground-shark or gurry-shark, the word 'gurry' being a local term for fish offal.

Scymnus, the typical genus of the family, is represented by a single species in European seas, while *Isistius* and *Euprotomicrus* are pelagic genera of tropical seas, of which but little is known.

The family Spinacidæ embraces the forms known as dog-fishes; its members are characterized by the absence of an anal fin, the presence of two dorsals, each bearing a spine in front, the gill-slits five in number, the spiracles moderate, and the third eyelid is absent. Among the internal peculiarities it may be mentioned that the centra of the vertebræ and the intervertebral tissue are distinct, and the vertebræ are strongly amphicœlous. About fifteen small species are known, mostly occurring in the Atlantic, and divisible into six genera, three of which are represented on the eastern coast of the United States.

Centroscyllium fabricii, the black dog-fish, belongs to the Arctic seas, and thence extends its range south to Massachusetts Bay. In this southerly portion of its habitat it is rare, but specimens have been taken off Gloucester by the members of the United States Fish Commission. In *Centroscymnus* the dorsal spines are small, and sometimes hidden beneath the skin. Nine species are known; one from the East Indies, the rest from the seas of Europe. One of these species, *C. cœlolepis* is caught off the coast of Portugal, in water from four to five hundred fathoms in depth. The fishermen use lines about six hundred fathoms long. Living at this great depth and its consequent pressure, they are killed by being drawn to the surface, and, when the fishermen take them into the boats, they are already without power of motion. The average length of this species is about four feet.

Our common dog-fish of the north-eastern Atlantic coast has a wide distribution, for it is found in Europe, while Dr. Günther regards the Californian *Squalus sucklii* as the same species. On our coast it bears several common names; picked dog-fish, bone-dog, skittle-dog, and hoe, while in scientific lore it is almost equally favored; though now the old name (*Squalus acanthias*) given it by Linné is restored. In color it is a gray or slate above, and lighter and even white beneath; in length it varies from one to three feet; and in weight from five to fifteen pounds. It is common on the coasts of Maine and Massachusetts; and on Cape Ann, at Boothbay, and other places there are fishermen who make it their sole business to fish for them. Indeed,

so abundant are they at times and in certain localities, they are caught by the thousand. On the Cornish coast, according to Günther, twenty thousand were once caught in a single haul of a seine. They are usually taken with a hook and line, but since their sharp teeth would instantly sever a cord, the hooks are attached to a short piece of chain or wire. These sharp teeth also render them a serious nuisance for the mackerel fishers, since, if they be entangled in a seine, they are very apt to sever the

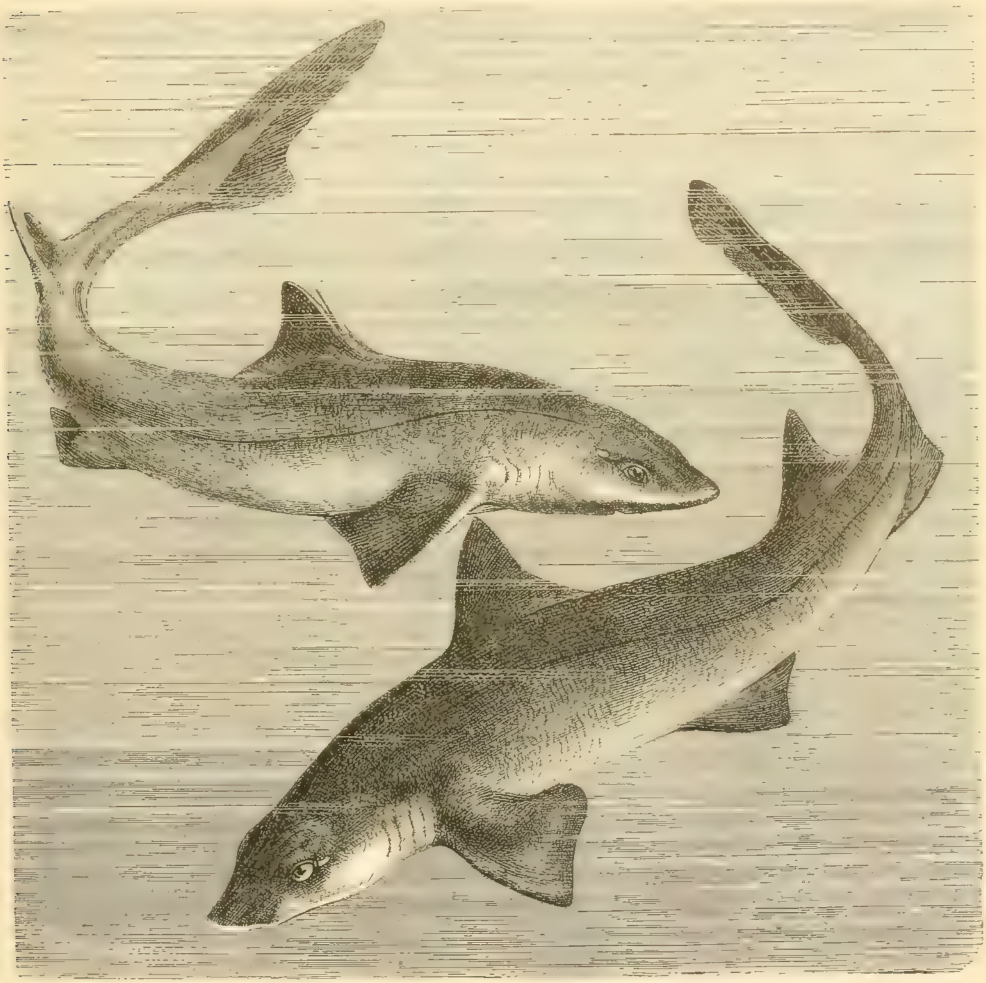


FIG. 60. — *Squalus acanthias*, dog-fish (above), and *Mustelus canis*, sea-hound (below).

meshes with their teeth; and besides they are very voracious and eat up large numbers of fish. On this account the fishermen in Massachusetts show them little mercy. As soon as caught, they rip them open, take out the liver, and then throw the dog-fish, still able to swim, back into the water, where they die a lingering death. We have already referred to the fact that the livers are used for the oil which they contain. It takes about a thousand livers, when large and fat, to make a barrel of oil, which is worth, say forty cents a gallon. In Maine, where the catching of dog-fish is more of an industry than in Massachusetts, the bodies of the dog-fish are saved, ground into

'chum,' and then this is converted into fertilizers. Experiments have also been tried to make the meat into food for poultry. In olden times, in the treeless districts of Cape Cod, the fishermen occasionally dried the dog-fish, and used them as fuel.

On account of the large numbers which are caught, this species is one which attracts the attention of the embryologist. During the months of July and August, almost every female contains a couple of transparent horny capsules, each containing from two to four eggs, and hence supplies for study are obtained with comparative ease. The embryos, in all stages of development, will live for some little time after being taken from the parent, if kept in salt water. The older embryos, when about six or ten inches in length, are spotted with large, round, white markings, which become much less conspicuous, or even disappear, in the adult.

The family PRISTIOPHORIDÆ, with its single genus *Pristiophorus*, and its four species, occurs in the Australian and Japanese seas. These forms have the front of the head prolonged into a very long flat blade, along each side of which is a series of teeth. This gives these sharks much the appearance of the common saw-fishes (which belong among the rays) but the differences between the two can readily be seen in the position of the gill-clefts. These saw-bearing sharks are smaller than the saw-fishes, and have a pair of long tentacles inserted at the lower side of the saw. They have no anal fin, and no nictitating membrane, but the spiracle is present. *Squaloraia*, a liasic genus, is supposed to belong near this family.

The CESTRACIONIDÆ is especially interesting to the geologist, because its members are so abundantly represented in the older rocks; twenty-two of the twenty-five known genera having lived in the ages preceding the oolite. The living genera are but poorly defined. Among the prominent characters of the family may be mentioned the existence of two dorsal fins, each with a spine, the presence of an anal fin, a small spiracle, and no nictitating membrane. The teeth are of several kinds, those in front being smaller and more acute than those farther back, which take on a pavement-like character. These molars are arranged in oblique rows, which vary in number and character, forming the basis of the division into genera. The mouth and nasal cavities are confluent.

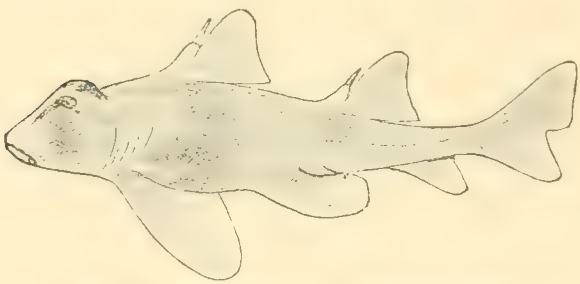


FIG. 61. — *Heterodontus galeatus*, Port Jackson shark.

The common name for the members of this family is Port Jackson sharks. All are confined to the Pacific Ocean, one species, *Gyropleurodus francisci*, occurring on the coast of California. The best-known genus is *Heterodontus* (= *Cestracion*). None of the four living species exceed five feet in length, but the extinct forms reached a much larger size. The oldest genus is *Ctenoptychius*, which appears in the Devonian rocks, and is succeeded in the carboniferous by a large series of forms. Judging by the character of the teeth, the members of this family live largely upon molluscs and crustaceans, though the more acute teeth in the front of the jaw would seem to indicate that these forms were not the whole of their food.

The RHINODONTIDÆ embraces only two species of large sharks, one of which well deserves the name whale-shark, which is applied to it. This species, *Rhinodon typicus*, of the Indo-Pacific region, "is known to exceed a length of fifty feet, but is

stated to attain that of seventy." It has an anal fin, two dorsals without spines, the first nearly opposite the ventral; both mouth and nostrils are near the extremity of the snout, and the spiracles are very small. Of *Micristodus punctatus*, only the jaws have been examined by a scientific person. This shark is stated to reach a length of twenty feet, and to be spotted; it occurs in the Gulf of California. In both *Micristodus* and *Rhinodon*, the teeth are very small, in the former genus the largest being but little more than a line in length and very numerous. This agrees well with what is reported of its habits, for it is said to feed upon *Laminaria* and other seaweeds, a statement which, however, needs confirmation. Should this prove not to be true, it will probably be found that minute marine animals constitute the food of these monsters.

The family LAMNIDÆ embraces a few large species of pelagic sharks, which agree in the presence of an anal and two dorsal fins, the latter being without spines, the first dorsal being opposite the interval between the pectoral and the ventral. The nostrils are separated from the mouth, and the spiracles are minute or absent. The family first appeared in the carboniferous period, and in the early tertiary almost all of the existing genera were represented.

The species of *Isurus* and *Lamna* are known as porbeagles. They are represented on our coasts by two or three straggling species, only one of which (*L. cornubica*) has been fully authenticated. The mackerel sharks of the fishermen belong here, but considerable confusion exists among them. They reach a length of ten feet, and annoy the fishermen not a little, by biting off their lines. Some forty or fifty years ago, the oil from the livers of mackerel sharks had a commercial importance and, according to Dr. Storer, one liver has been known to make eleven and a half gallons of oil, and eight livers to produce a barrel. At the present time, shark oil is not quoted, but it is used to adulterate the cod oil used by the curriers.

The porbeagles and mackerel sharks are separated from the others of the family by the moderately sized gill-openings, and the well-developed teeth, the edges of which are entire. The man-eater sharks (*Carcharodon*) have the edges of the teeth serrated. Of this genus, only a single species is known, *C. rondeletii*, but this occurs in all temperate and tropical seas, though it is very rare on our coasts. The specimen seen by Dr. Storer measured thirteen feet in length, but the species is known to reach a length of forty feet. Notwithstanding its size, comparatively little is known of this monster, and it may be that individuals exist of larger size than that just mentioned. In a specimen thirty-six and a half feet in length, the teeth measured one and three quarters inches on the base, and two and a half inches on the lateral margin. The 'Challenger' expedition frequently dredged, between the Polynesian islands and the west coast of America, *Carcharodon* teeth with a base of four inches and a side of five. Nothing is known of any recent species which attains anything like the dimensions that this would indicate, but if the species to which they belong is extinct, the position and condition of the teeth dredged shows that it must have died out at a comparatively recent period. In the various rocks of the tertiary period, *Carcharodon* teeth are numerous, and indicate, apparently, the existence of several species, some of which must have reached enormous dimensions.

The single species of *Cetorhinus* (*Selache*), *C. maximus*, has received the common name, basking-shark, from the fact that at certain seasons it collects in large schools, which lie motionless, the dorsal fins and the backs rising above the surface of the water. It is one of the largest of the sharks of the North Atlantic, occasionally reaching a

length of thirty feet. Its teeth are small, and it feeds principally on fish and other marine animals, and but rarely attacks man. When aroused, it is a dangerous customer, not so much on account of its teeth, as from the violent strokes of its tail, which will break in the sides of a whale-boat. Its liver makes a large amount of oil, six barrels having been obtained from a single shark.

Considerable confusion exists concerning the species of *Carcharias*, from the fact that the generic term has been used by different authors for greatly different sharks. As here employed, it is the equivalent of the genus *Odontaspis* of some, while their *Carcharias*, is, in the present work, the genus *Carcharinus*. But three species of the genus are known. They are pelagic, and occur in the temperate and tropical seas, *C. americanus* being the sand-shark, gray-shark, or shovel-nose of the Atlantic coast. It is a small species, rarely exceeding six feet in length, but its size is in no way commensurate with its appetite, it being one of the most voracious of all the group. It may be separated from all others of this family occurring on our coast, by having moderate-sized gill-openings, all of which are in front of the pectoral fins. In color it is gray, and its teeth are sharp and awl-shaped.

The thresher shark, *Alopias vulpes*, is readily recognized by its extraordinarily long tail, which forms over half the length of the whole animal. It is distributed in both Atlantic and Pacific oceans, but, though occasionally taken in California and New Zealand, it is much more common in the Mediterranean and on our eastern coasts. It is a migratory shark, but its migrations are dependent upon the shoals of mackerel, menhaden, herring, or other fish on which it feeds. "When feeding, it uses the long tail

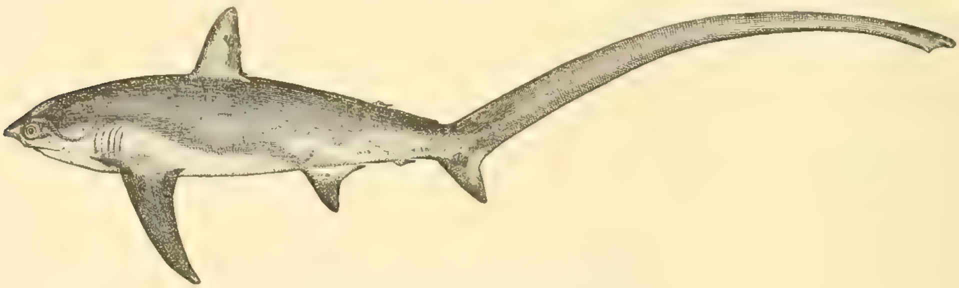


FIG. 62. — *Alopias vulpes*, thresher shark.

in splashing the surface of the water, while it swims in gradually decreasing circles round a shoal of fishes, which are thus kept crowded together, falling an easy prey to their enemy. Statements that it has been seen to attack whales and other large cetaceans rest upon erroneous observations." The powerful stroke it gives with its tail explains the terms, thresher and swingle-tail, which are usually applied to it. It is occasionally taken by the fishermen, but its powerful strokes render its capture a difficult matter, while the small amount of oil in its liver poorly rewards the labor necessary to obtain it. It reaches a length of about fifteen feet; above, it is bluish lead-color, beneath, white.

The SPHRYNIDÆ embraces the hammer-headed sharks, the most peculiar of the order. In most of their features they resemble the next family, the Galeorhinidæ, but their peculiar heads at once separate them. They have an anal fin, two dorsals without spines, the first being behind the ventrals, and no spiracle; the head is expanded, on either side, into a broad lobe, and on the ends of these lobes the eyes are

placed, giving the animal the appearance of a hammer, or, better, a mallet. The five known species are arranged in two genera, but the most common and best known species is *Sphryna zygæna*, the *Zygæna malleus*, of most books. This species is cosmopolitan, mostly frequenting the warmer seas of the world, but occasionally appearing on the coasts of Old and New England. It reaches a length of fifteen feet, is brownish gray above, and dirty white beneath. Its common food is skates, flat-fish, and other bottom feeders, but it does not hesitate to attack man when the opportunity offers. It is difficult to say what causes have given rise to its peculiarly shaped head. Our other species, *Sphryna tiburo*, is smaller, and has the head regularly rounded in

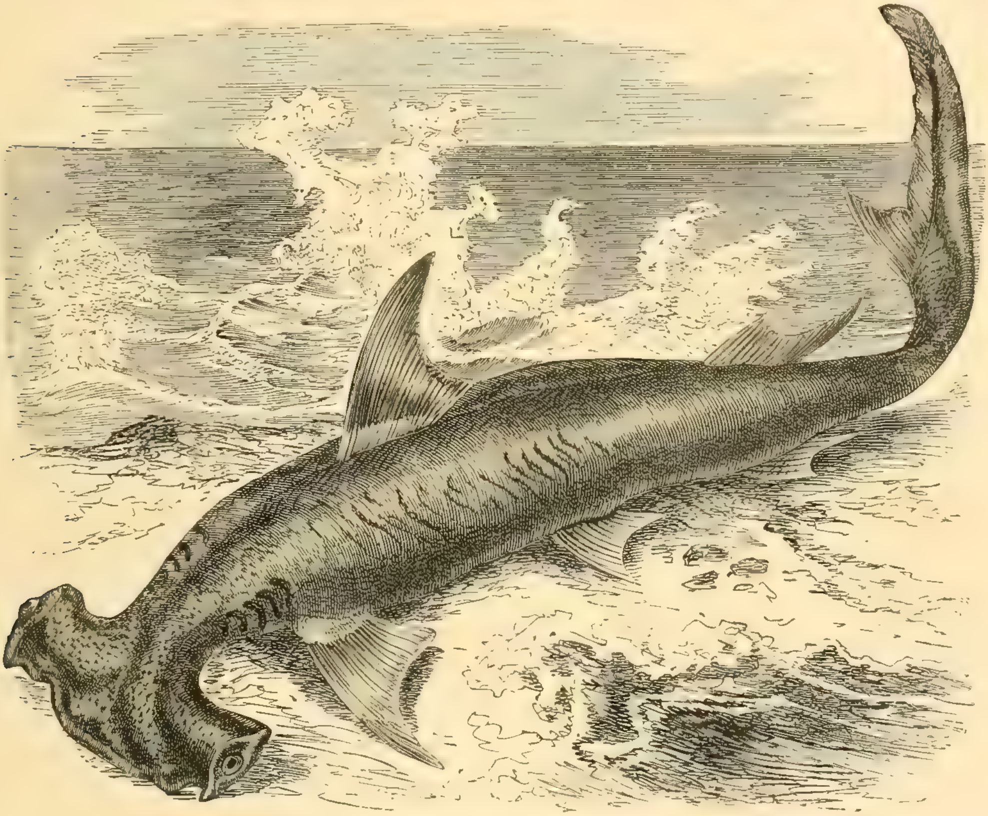


FIG. 63. — *Sphryna zygæna*, hammer headed shark.

front, whence the common names shovel-head shark and bonnet-shark. It is a smaller species, reaching a length of six feet. It occurs in the Atlantic, and extends its range to China.

The GALEORHINIDÆ is a large family embracing over a third of the known species of sharks, distributed in about twenty genera, of which eleven are represented on the coasts of the United States. All agree in having an anal and two dorsal fins without spines, a moderate caudal, the last gill-slit above the base of the pectoral, and nictitating membranes; the head is normal and not produced on either side, as in the last family.

The genera *Mustelus* and *Rhinotriacis* differ from the rest of the American forms in having the teeth flat and pavement-like, and from many in the presence of spiracles.

Best known is the smooth hound, or dog-shark, *Mustelus canis*, figured on page 77, together with *Squalus acanthias*. It is a small species, the smallest of the American sharks, rarely reaching a length of four feet. In its range it includes the Atlantic coasts of both continents, on our shores being more common south than north of Cape Cod. It also occurs on the coast of California, where it was originally described as a distinct species under the name *M. californicus*. It is harmless, and feeds on the crabs and shells which abound on the bottom in favored localities. From its resemblance to the dog-fish, it is often confused with that species, but is readily separated by the lack of spines in front of the dorsal fins.

In the genus *Mustelus* all the teeth are obtuse, and there is no internal connection between the mother and the embryos. The young are born alive, sometimes a dozen at a birth.

In the genus *Rhinotriacis* of which *R. henlei* occurs on the Pacific, and *R. lævis* on the Atlantic coast (the latter being more properly an European species), the teeth are sharper, some having basal cusps, while a placenta is developed to assist in nourishing the growing embryo. In Europe, and especially in Italy, the species both of *Mustelus* and of *Rhinotriacis*, are eaten by the poorer people, although the flesh is not very palatable. Both share the name of hound, and smooth dog-fish. This application of the names dog, hound, porbeagle, etc., to different species of sharks, is doubtless due to their following their prey in packs.

The remaining genera to be mentioned of the family have the teeth acute, and with sharp edges. The genus *Galeorhinus*, or *Galeus*, frequents the warmer waters. *G. galeus* is called tope in England; it extends its range to Tasmania and California, but has not yet been found on the east coast of the United States. In California it is common, and has received the common name of oil-shark. It proves itself a nuisance to the fishermen, since it not only takes the bait itself, but drives away the other fishes. The topes are small sharks. The species of *Galeocerdo* are larger. *G. tigrinus* occurs on both Atlantic and Pacific coasts, and derives its common name tiger-shark from its variegated coloration.

The genus *Carcharinus* embraces the blue-sharks, the sharks of story. The species are numerous, especially in the warmer seas, and if we take the genus in its wider sense, it embraces about forty nominal species. The genus may be separated from the rest of the family by the serrated well-developed teeth, and the absence of a spiracle. The great blue-shark, *C. glaucus*, is the best known of the genus; it ranges through all the seas, and occasionally occurs on the coast of the eastern states, as well as on the Californian shore. In size it commonly reaches a length of about fifteen feet, but individuals twenty-five feet or more in length are sometimes seen. It is blue above, and white beneath. The white-shark, *C. vulgaris*, is even larger, a specimen thirty-seven feet in length, having been known. Its color is grayish-brown above, and white below. It is an inhabitant of the tropical seas, and is but rarely seen in temperate zones. More common on our coasts is the dusky-shark, *C. obscurus*, which rarely exceeds ten feet in length, and, like the great blue-shark, is blue above. An important difference exists in the position of the dorsal fins in the two. In *C. glaucus*, the dorsal is midway between the pectorals and ventrals, and in the dusky-shark, it is placed close behind the root of the pectorals. These facts, as well as the existence of a placenta, have led Dr. Gill to separate it and a few other species, as a distinct genus, *Eulamia*.

The species of *Carcharinus* share with the species of *Carcharodon* the name

man-eater sharks. We need but refer to their well-known habit of following ships for weeks, feeding on the refuse that may fall overboard, and not hesitating to swallow any object, however impalatable or indigestible, that may come in their way. Their voracity is unbounded, and they swim with great velocity. Their cartilaginous skeleton gives the body great flexibility, and the tail can be bent, unlike that of the true fishes, into a compound curve. Did space allow, we could retail many a story of their omnivorous appetites. In the stomach of a white-shark was found a tin can, a number of mutton bones, the hinder quarters of a pig, the head and fore quarters of a bull-dog, a quantity of horse-flesh, and other and smaller things — as the auction bill says — too numerous to mention. Possibly the most interesting case is the following, with which we must close our account. The story is well authenticated. A British cruiser was following a suspected slaver off the African coast, but, on overhauling her, nothing was found to implicate the vessel in any illegal practice. A white-shark was caught about this time, and in its stomach were found the slaver's papers, which had been thrown overboard, and which conclusively settled the guilt of its owners and officers. On long voyages, a favorite amusement to while away the time is fishing for sharks. A large hook is fastened to a piece of chain, and baited with pork or other meat. This the shark usually swallows in a hurry. When hauled on board, the work is not done; his tail, as well as his teeth, are formidable weapons. One of the bolder sailors usually rushes quickly up, and, with a sudden blow with a hatchet, cuts the body just in front of the caudal fin, which puts an end to danger from that source. The meat of these large sharks is usually described as coarse and unpalatable. The whalers, however, like it, and describe it as much like that of halibut. Possibly, their long diet of salt meat contributes to their appetites.

The Scyllidæ have an anal and two dorsal fins, the latter without spines; the first dorsal is above or behind the ventrals, the teeth are small, and those of several rows are generally used at the same time; there is no nictitating membrane, and a spiracle is well developed. The species of the typical genus *Scyllium*, share with *Squalus* the common name dog-fishes, but this introduces no little confusion, since the two are so different, and hence the term roussette is perhaps preferable. The roussettes, unlike the dog-fish, are oviparous, their eggs being enclosed in quadrangular horny cases, prolonged at each corner into a long filament, which coils around seaweeds and other submarine objects, and thus anchors the egg.

Our only species of *Scyllium* is the swell-shark, *S. ventricosum*, of the west coast of Mexico. This species is peculiar in that, when caught, it swallows air like a sculpin or a sea hedgehog (*Diodon*), until its diameter equals a third of its length. The cat-shark, and dog-shark, *S. catulus*, and *S. canicula*, of European seas, are handsome species, reddish in color, and spotted with numerous brown blotches. They are great enemies of the herrings. They are found most abundantly among the Orkney Isles, and are there used to a considerable extent as food. Their flesh is very white, but dry. The fishermen split them open, and dry them, in much the same manner as they would a cod-fish. This species also furnishes most of the shagreen used by cabinet-makers.

The genus *Stegostoma* is noticeable from the fact that its only species, *S. tigrinum*, is one of the most beautiful sharks known. It reaches a length of about fifteen feet, and is brownish yellow, over which are laid black or brown transverse bands, or round snuff-colored spots. It is one of the most common species in the Indian Ocean, and, from its ornamentation, has received the common names zebra-shark and tiger-shark.

The SQUATINIDÆ, or angel-sharks, embraces forms which closely approximate the rays in appearance. They have a flattened body, with very large pectoral fins, which project far out on either side, giving the whole a rhomboidal appearance; behind the pectorals are two dorsal fins; the mouth is at the end of the head, and the lateral gill-clefts are partially concealed by the base of the pectoral fin.

The angel-fish or monk-fish, *Squatina angelus* (or *Rhina squatina*), is found in almost all the temperate and tropical seas. It grows to a length of about five feet, and frequents the bottom, where it feeds upon fishes, rays, and the like. It is remarkably voracious. It brings forth its young alive, sometimes to the number of twenty at a birth. The time of reproduction is not settled; some say it is in the spring, others in the fall; both may be true. The name angel-fish is only appropriate if we regard the pectoral fins as wings; in all other respects the appearance is anything but angelic.

ORDER II. — RALÆ.

As was said on a previous page, when treating of the sharks, the only prominent constant character separating the sharks and skates was to be found in the position of the gill-clefts; lateral in the one, ventral in the other. Besides this, however, there are several others which are more or less constant, and really of more importance than this one. Among these we may mention the flattened, depressed body, from which the broad, expanded pectoral fins are scarcely distinct, while the tail is usually long and slender, and appears as an appendage, rather than an integral part of the whole. There are no anal fins, and the dorsals, when present, are confined to the tail. The skeleton of the pectoral fins is united to the skull by cartilage, and the median articular facet between the skull and the first vertebræ is lacking.

So far as is known, all of the rays are carnivorous, but only the shark-like forms (saw-fishes and the Rhinobatidæ) actively pursue their prey. These forms are strong and rapid swimmers, but the true rays live on the bottom, and swim solely by the undulations of the edges of the pectoral fins, as is shown in the upper figure of *Raia batis*, on page 86. These must perforce live on shell-fish, crabs, flounders, and other forms that frequent the bottom, and for this the mouth is well fitted. It is placed on the ventral surface, so that, were it not for a capacity of movement of the jaws, it could not readily take its prey. The ray swims rapidly over a fish, and then settles down upon it, holding it from escape with its broad body; then, by suitable muscles, the jaws are protruded beyond the rest of the surface, and the object is taken in. The statement often made, that the prey is not directly seized by the jaws, is not correct of some — if, indeed, of any — of the species. The difficulty of observing their eating habits has caused the mistake.

According to Dr. Günther, the rays do not frequent deep waters, only one having been known to occur in water over a hundred fathoms in depth. This exception was said to have been dredged in 565 fathoms by the 'Challenger' expedition. About one hundred and fifty species are known, but none of these have a geographical range to compare with that of many sharks. They are more restricted, and almost all of them may be considered shore forms, only the eagle rays being found far from land. The rays are not confined to salt water, but several forms, especially in South America, occur in fresh water far inland.

Most of the species are usually said to be oviparous, but, according to Dr. Gill, about three quarters of the known species bring forth their young alive. The eggs

have the same square appearance, with long filaments at the corners, as was described on a preceding page, for *Scyllium*. The eggs are not infrequently thrown up upon the beaches, and have the common name sea-purses. In England the term 'shark-barrows' is in common use, from their diminutive resemblance to a hand-barrow. The development of the rays has been studied by several, but the paper by Jeffries Wyman is the best known in America. In the earlier stages the young skate is much like a shark, and the enormous development of the pectoral fins, and the assumption of the ray form, does not occur until nearly the time of hatching.

Most curious of all the rays are the saw-fishes (PRISTIDÆ) so abundant in the tropical seas. In general appearance, they closely resemble the Pristophoridæ among the sharks; they have a shark-like body, while the snout is horizontally flattened and projects far beyond the mouth. On the edges of this snout, stout teeth are inserted, so that the resemblance to a saw is all but complete. The saw-fishes are among the most formidable of the order, for this singular weapon places all the other large inhabitants of the sea at their mercy. With it, the saw-fish cuts and slashes, tearing off pieces of flesh, or ripping open the abdomen of its opponent. The saw is sometimes very large, reaching a length of six feet, and a breadth of twelve inches. The teeth of the jaws are so small as to unfit the animals for a predacious life, were it not for the saw. The pieces which this tears off are readily swallowed. The saw-fish is a great enemy of the whale.

Five species of the single genus *Pristis* are known; distinguished among each other, among other points, by the number of teeth in the saw. *P. pectinatus*, with twenty-five to twenty-eight pairs of teeth, occasionally occurs on our southern coasts and in the Gulf of Mexico, occasionally ascending the lower Mississippi. *P. antiquorum* occurs in Lake Nicaragua as well as in the tropical oceans. The saw-fishes are viviparous, though but little is known of their development. The saw and its teeth are developed before the young leaves its mother's body. The flesh of the saw-fish is coarse and unpalatable, though it is occasionally used as food in time of need. The shagreened skin is put to the same uses as that of sharks.

The RHINOBATIDÆ are also somewhat shark-like, the anterior portion of the body not showing that excessive development to be found in the other families of the order, and the pectoral rays are not continued to the snout. The tail is large and strong, and bears two dorsals and a well-developed caudal fin. All bring forth their young alive. It contains some fifteen or twenty species, inhabiting the warmer seas. Our fauna contains four species, all belonging to the genus *Rhinobatus*, three on the west coast, and one in the waters around Florida. They are not well known.

The interest in the family TORPEDINIDÆ centres in their electric powers. As we shall see farther on, they are not the only vertebrates capable of generating electricity, and, in fact, they are less celebrated in this line than are the electric eels of South America. Still their powers in this respect are not to be despised. The torpedos have a broad, smooth, disc-like body, from which arises a stout tail, with a longitudinal fold on either side; usually a dorsal, strengthened by rays, is present, while a caudal always occurs.

The electrical organ consists of two large masses of hexagonal prisms, looking much like the comb of the honey bee, placed one on either side, between the head and the pectoral fins, and covered by the integument. The prisms are vertical, and each is divided by transverse partitions into a number of cells. Lining the inside of the cells is a layer of connective tissue, which bears the nerves and blood vessels; inside of this a nucleated epithelium, and within this a clear, transparent, almost jelly-like

fluid. The nervous supply is very large, the nerves which run to the organs being enormously developed. Each organ receives one branch of the trigeminal, and four branches of the vagus, nerves. The number of prisms is very large, nearly five hundred having been counted in a single organ. These electric organs have been extensively studied, and the evidence goes to show that they are composed of extremely modified muscles. This is shown not only by their anatomy and development, but by their physiological action. Says Dr. Günther: —

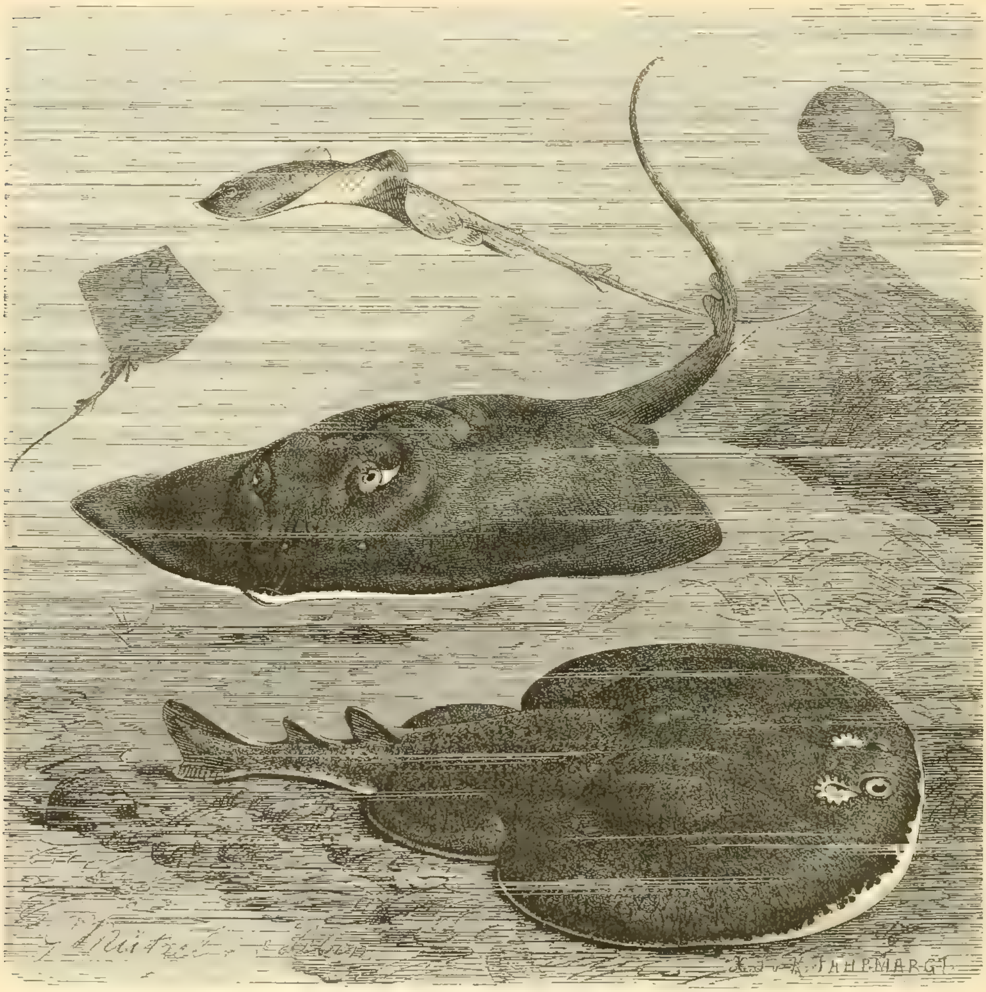


FIG. 64. — *Raia batis*, common European skate, and *Narcacion marmorata*, spotted torpedo.

"The phenomena attending the exercise of this extraordinary faculty also closely resemble muscular action. The time and strength of the discharge are entirely under control of the fish. The power is exhausted after some time, and it needs repose and nourishment to restore it. If the electric nerves are cut, and divided from the brain, the cerebral action is interrupted, and no irritant to the body has any effect to excite electric discharge; but if their ends be irritated, the discharge takes place, just as a muscle is excited to contraction under similar circumstances. And, singularly enough,

the application of strychnine causes simultaneously a tetanic state of the muscles, and a rapid succession of involuntary electric discharges. The strength of the discharges depends entirely on the size, health, and energy of the fish; an observation entirely agreeing with that made on the efficacy of snake poison. Like this latter, the property of the electric force serves two ends in the economy of the animals which are endowed with it; it is essential and necessary to them for overpowering, stunning, or killing the creatures on which they feed, while incidentally they use it as the means of defending themselves from their enemies."

The current of electricity generated by these organs will deflect or magnetize a needle, and decompose iodide of potassium, while, when favorably arranged, it can be made to produce a spark. To get a shock, one needs to complete a circuit just as with a galvanic battery or a Leiden jar. The dorsal surface of the organ is positive, the ventral negative. The discharge from a large individual is sufficient to temporarily disable a man, and were these animals at all numerous they would prove dangerous to bathers.

Some six genera and about fifteen species of torpedos are known, but only two genera, *Narcacion* (= *Torpedo*), and *Narcine*, occur on our coasts. *Narcacion occidentalis* is occasionally found on the Atlantic coast, both north and south of Cape Cod, and has recently been found in European waters. It is almost black above, and white below, and reaches a length of nearly five feet. A second species, *Narcacion californica*, occurs around San Francisco. Besides *N. occidentalis*, three other species occur in the waters of Europe, *N. marmorata* being the most common.

From *Narcacion*, the genus *Narcine* is separated, among other characters, by the fact that it has the second dorsal the larger, and the spiracles very near the eyes. *Narcine braziliensis* ranges from Florida to Brazil, the northern forms showing some variations in color, which have led to the creation of a varietal name (*corallina*) for them.

The typical family of rays is the RAIIDÆ, all the members of which are oviparous. Their numbers are greater in temperate than in tropical seas, and the northern hemisphere contains many more species than the southern. All agree in having the body broad and rhomboidal in outline, and the pectoral fin continued to the snout; on the sides of the tail is a lateral fold like that in the torpedos, but, unlike these forms, an electric organ is absent, and usually the skin is roughened with granulations or spines. Four genera, and about fifty species, are known from the existing seas; the genus *Raia* alone is represented on our shores. Of the nearly forty known species of this genus, nine species occur on the east coast of the United States, and six on the west. They all have the tail distinct from the trunk, the caudal fin rudimentary or absent, the pectoral fins of the opposite sides not united across the snout, and the pectorals deeply notched. The skin is more or less spiny, and the teeth differ with the sex.

The rays, or skates, as they are variously termed, are bottom-feeders, swimming slowly along just above the sand or mud. They readily take the hook, and are frequently caught, though little or no economic use is made of them on our eastern coasts. They are, in reality, an important source of food, neglected, like many other products of the sea, by the inhabitants of the United States. The fisherman, when he catches a skate, jabs a boat-hook or pocket-knife through it, and throws it overboard. To him, it is an ugly creature that steals his bait. In Europe, and among some of our foreign population, skates are more highly esteemed, the fins being deemed the best portions.

Any detailed description of our species would prove dry reading. The most common species on the east coast is *Raia erinacea*, which, for some vague reason, is called among other names, the 'tobacco-box.' It rarely exceeds two feet in length. *R. eglanteria*, the brier skate, has the spines on the body and tail very sharp. *Raia lævis*, the smooth skate, or barn-door skate, is our largest east-coast species, reaching a length of four feet. In the young the surface is spiny, but in the adult it is nearly smooth. The largest of all the American species is *R. binoculata*, of the Pacific coasts, which grows to be six feet in length; its egg cases are proportionately large, measuring nearly a foot in length. More common in California is the smaller *R. inornata*.

FIG. 65. — *Raia lævis*, smooth skate, barn-door skate.

The family TRYGONIDÆ embraces the sting-rays, so-called from the spines borne on the base of the tail of some species, which are capable of inflicting a severe wound. These spines are the representatives of the dorsal fin, which is otherwise absent. The most anterior spine is the functional one, and is used for offence and defence. In the larger species it may grow to be eight or nine inches long, and is armed with barbs or serrations like the teeth of a saw. As the teeth wear out, the spine drops off, and is replaced by the next one behind; the succession recalling that occurring in the teeth of the Plagiostomes. These barbs cut their way through the skin and flesh, the wound they produce being very painful, swelling up as if poisoned. No trace of any poison glands has been found, but it is probable that the mucus of the surface of the fish possesses poisonous qualities, as it does in the case of the horned-pout, the weaver fishes, and many of the Scorpænids.

Besides this character, the Trygonidæ may be recognized by having the pectoral fins confluent across the snout, no lateral folds on the long and slender tail, and the pavement-like teeth usually more or less pointed or tubercular. There are about ten genera, and about fifty species, mostly occurring in tropical seas, comparatively few straying into the more temperate waters. Some occur in the fresh waters of Central and South America. All are ovoviviparous.

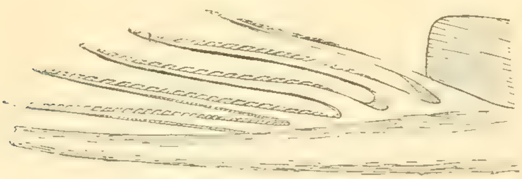


FIG. 66. — Spines of sting ray.

Most common on our coasts are the species of *Dasybatus* (= *Trygon*), the fauna of the United States embracing six of the thirty known species. In the young stages the skin is frequently smooth, but with growth it becomes more or less spiny

or prickly. The single known species of *Urogymnus* (*U. asperrissimus*) occurs in the Indian Ocean. "The skin is frequently used for covering shields and the handles of swords and other weapons, its rough surface offering a firm hold to the hand." The Chinese also use the skin in some of their ornamental work; they dye it with some color, and then polish the surface, grinding off the asperities. The pattern thus produced is very handsome, the bony plates and intervening tissue producing a mottled appearance. The genus *Potamotrygon* contains the fresh-water rays of tropical America. The species of *Urolophus* have the body more or less circular in outline; one species, *U. torpedinis*, occurs as far north as New Jersey, and two others are found on the Pacific coast of the United States. They have the serrated spine at the base of the tail well developed.

The eagle-rays and sea-devils (MYLIOBATIDÆ) have a very broad disc and a peculiar development of the fins. The pectorals stop short of the snout, and then reappear as 'cephalic fins' at the extremity of the head. In some, these take on almost the character of limbs, are flexible, and are said to be used in scooping up food from the bottom, and transferring it to the mouth, which lies between and behind them. All have the teeth flat and pavement-like, without cusps or tubercles (except in the sea devils), forming a perfect mill for crushing shells and crabs. The species mostly occur in tropical and semi-tropical waters; they bring forth their young alive. The largest species belong to the genera *Dicerobatis* and *Manta*. "Some of them, if not all, attain an enormous size. One mentioned by Risso, taken off Messina, weighed 1250 pounds. Several observers speak of having seen them in pairs, the male being usually the smaller. Of a pair mentioned by Risso, the female was first taken, and the male remained hovering about the boat for three days, and was afterwards found floating dead on the surface. Still larger individuals, but of uncertain species, are mentioned by Lacépède, who says that one taken at Barbadoes required seven yolk of oxen to draw it. A sketch of another, which was said to be twenty feet long, was sent to Lacépède; and Sonnini speaks of one which appeared to him to be longer and wider than the ship in which he was sailing. A fœtus taken from the uterus of the mother captured at Jamaica, and preserved in the British Museum, is five feet broad, and weighed twenty pounds. The mother measured fifteen feet in width, as well as in breadth, and was between three and four feet thick. The capture of 'devil-fishes' of such large size is attended with danger, as they not rarely attack and capsize the boat. They are said to be especially dangerous when they accompany their young, of which they bring forth one only at a time."

In the waters of tropical America, in both Atlantic and Pacific, and ranging as far north as North Carolina and San Diego, occurs the monstrous *Manta birostra*, probably the same species as that mentioned above from Jamaica and Barbadoes. It has been described under various names, some of which are indicative of its unenviable reputation. Such are *Diabolichthys* and *Vampyrus*, while the generic name *Manta* (a blanket) is a "name used at the pearl fisheries between Panama and Guayaquil, to designate an enormous fish much dreaded by the divers, whom it is said to devour after enveloping them in its vast wings."

The species of *Myliobatis*, *Stoasodon* (=*Ætobatis*), and *Rhinoptera* are much smaller than the sea-devils; still, some reach a considerable size. Like them, they have a long slender tail, like a whip-lash, but the teeth are much larger, and never tubercular. Each of these genera are represented on our coasts.

J. S. KINGSLEY.

CLASS V. — PISCES.

Comparatively recent investigations show that the old group of fishes, the Pisces of the older systematic works, needs to be dismembered. Forms like Amphioxus and the lampreys are fully as different from the ordinary types of fishes as are the Batrachia from the reptiles, or the latter from the birds. But exactly where or what lines shall be drawn, science has not finally determined. For the present, however, it seems best to restrict the term fishes or Pisces (its Latin equivalent) to the series of forms embracing the great majority of forms now living, which have the following characters in common: —

The skeleton may be either cartilaginous or hardened by the deposition of salts of lime in its tissues. The skull is well developed, the bones or elements of which it is composed are united by sutures, and a lower jaw is present. The gills are normally four in number, and are borne on bony arches. The water, after passing though the mouth and over the gills, goes out through a single slit on either side. The body is usually covered with scales, and on the heads of some membrane-bones are developed. Both median and paired fins are usually present. Normally, and in the young, the former forms a continual fin around the body, beginning behind the head, passing back around the tail, and forward on the ventral surface as far as the vent; but usually it is, in the adult, broken up into several portions, known, according to their position, as dorsal, caudal, and anal fins. The paired fins are always in two pairs, corresponding to the two pairs of limbs of the higher vertebrates. Those representing the fore limbs are called the pectoral, those homologous with the hind legs are known as the ventral fins. The brain is larger than the rest of the nervous system, and is divided into three portions, the fore, mid, and hind brains. A well-developed heart is present, consisting of an auricle, a ventricle, and a bulbous arteriosus, the latter having a varying number of valves in its interior.

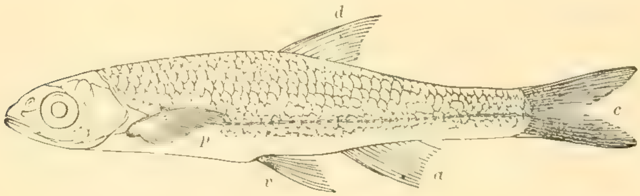


FIG. 6[illegible]. — Fins of a fish; *a*, anal; *c*, caudal; *d*, dorsal; *p*, pectoral; *v*, ventral. (The first three are known as median, the others as paired fins.)

Of the Pisces, two divisions are usually recognized, the ganoids and the teleosts. In some respects one, in others the other, of these seems to be the more highly differentiated, though it is evident that the latter have deviated the more widely from the primitive stock from which the other types of vertebrates have arisen. With this uncertainty before us, it is of little importance which we take up first, and so, from convenience, we begin with the Ganoidea.

SUB-CLASS I. — GANOIDEA.

The ganoids receive their name from a Greek word meaning splendor, in allusion to the enamelled armor with which most of them are encased. As first defined it embraced several forms now recognized as teleosts, a mistake arising from the fact that

all fishes were divided into four groups, ctenoids, cycloids, placoids, and ganoids, based on the character of the scales. When, however, a single fish was found bearing on its body two of these types of scales, the artificiality of this basis of classification was at once recognized, and to-day only the term Ganoidea remains as a memento of the former ideas. To-day it is not one single character which is used to define the group, but all known facts of structure and development, and even then its limits are far from well defined, especially in the direction of the teleosts. Indeed, but one single character can be adduced to separate every ganoid from every teleost; the presence of a spiral valve in the intestine in the former, and its absence in the latter, and even this does not hold good in all cases, for, besides being found in the lampreys, which we have passed, and in the sharks, which we have yet to study, it exists in but a rudimentary condition in *Amia* and *Lepidosteus*. All the other characters mentioned below have an exception somewhere.

The external surface is but rarely naked, but is usually covered with bony scales or plates, which in the sturgeons are large and separate, but in the shovel-nosed sturgeons they form a solid coat of mail enveloping the tail. Frequently the scales are rhomboidal in outline, but in some they are round and much like those of the teleosts. In some the skeleton remains almost entirely cartilaginous, but in others ossification sets in to a greater or less extent. Thus in some the cartilaginous skull is protected by membrane bones, and the framework of the jaws is hardened. In others the ossification extends to the vertebræ and to other parts. The pectoral fins usually are well developed, and in the fossil forms attained a peculiar development. The caudal fin is usually heterocercal, that is, the vertebral column extends into the upper lobe, the lower lobe remaining much smaller, but in others the two lobes are equal. This point was formerly much emphasized in the arrangement of fishes, as in the young teleosts a heterocercal condition was noticed which disappears in the adult. Mr. Ryder has recently explained, on mechanical grounds, the causes of the heterocercal condition. Frequently one or more of the fins are armed in front with a series of overlapping spiny plates, known as fulcra. The existence of these in a fossil is of great value in determining its relationships, and one author has said that "every fish with fulcra on the anterior margin of one or more fins is a ganoid."

The heart is furnished with a bulbus arteriosus, which pulsates and is internally furnished with a number of valves, the purpose of which is to prevent the blood flowing back during the pause in the beat. An air-bladder is present, and is furnished with a duct leading to the œsophagus. The optic nerves do not simply cross, as in the teleosts, but unite to form a chiasma like that occurring in the higher vertebrates.

The ganoids are an ancient group, well developed in the paleozoic rocks, but now dying out. The fossil genera are numerous, and the species frequently highly differentiated, but to-day only eight genera and between thirty and forty species comprise the ganoid fauna of the world. With its great antiquity and generalized condition, the group presents resemblances to many others. On the one hand some of its members approach the Holocephali among the Elasmobranchs, while, on the other, forms like *Amia* show a distinct teleostean tendency. Still others appear to reach out towards the lung fishes.

Seven orders of ganoids are recognized, three of which, Acanthodini, Placodermi, and Pycnodontina, are extinct. They appeared in the Silurian and Devonian rocks, and represented the ichthyc type in the age of fishes.

ORDER I.—ACANTHODINI.

This order seems to represent the connecting links between the ganoids and the Selachii, or sharks and skates. The forms belonging to it (embracing the genera *Acanthodes*, *Chiracanthus*, *Diplacanthus*, etc.) flourished in the Devonian and carboniferous periods of geological history. They had cartilaginous skulls, heterocercal tails, rhomboidal scales which were so small that they gave the exterior a shagreened appearance, and before each fin they were armed with a large spine.

ORDER II.—PLACODERMI.

The members of the Placodermi (or, as the order is sometimes termed, Phractosomata) were armored fishes, which had the head and thoracic region enclosed in great bony plates, the external surface of which was variously sculptured. These plates were closely united, so that the whole formed a perfect protection to the viscera. In some the tail was naked, but in others it was covered with ganoid scales. The armor also extended to the pectoral fins, which in some forms were so enclosed in the hardened plates, jointed for motion, that they resembled the appendages of a crustacean. The bodies of the vertebræ were not ossified. These fossils are found in the Silurian and Devonian rocks, and are the oldest vertebrates whose remains are known to the geologist. Some of the forms were very large. *Dinichthys*, a genus from the Devonian strata of Ohio, reached a length of from fifteen to eighteen feet, while *Astrolepis*, from the corresponding rocks of Europe, measured between twenty and thirty feet. Some doubt exists regarding the position of *Dinichthys*; Professor J. S. Newbury, from a consideration of the teeth, regarding it as related to the lung-fishes (Dipnoi). Two families are recognized, the first, PTERICHTHIDÆ, having the head covered by several bony plates, the other, the CEPHALASPIDÆ, having but a single large plate in the same region.

ORDER III.—CHONDROSTEI.

The sturgeons first appear in rocks of the eocene age, and hence, so far as we know, are the latest group of ganoids to appear. They are distributed through the waters of the northern hemisphere, only four genera and less than twenty-five species being known. In all the skeleton is largely cartilaginous, and the notochord persists through life; the skull is cartilaginous and covered with membrane bones. The skin in some is naked, in others it is covered with bony plates in the place of scales. The tail is heterocercal, and the caudal fin is armed in front with the bony spines or scales already described under the name fulcra. Two families (by some regarded of higher rank, and called Selachostomi and Glanostomi) exist at the present day.

In the ACIPENSERIDÆ we find fishes with elongate bodies protected with five rows of large bony plates, one running along the dorsal line of the body, one on each upper lateral and each lower lateral surface. Each plate has a longitudinal ridge or carina crossing its middle, and terminating in a more or less acute spine. Between these large plates are smaller irregular plates, which render the surface rough. The snout is flattened and extends to some distance in front of the mouth, and from its lower surface hang down four flexible filaments or barbels, arranged in a transverse row. These

barbels are somewhat like those of the horned pouts (Siluridæ), whence the subordinal name, Glanostomi, referred to above. The small transverse mouth is toothless, and can be protruded for the purpose of feeding.

The genus *Acipenser* embraces the sturgeons, the largest fishes found in fresh water. It is distinguished from the only other genus by having a flattened conical snout, a spiracle above each eye, and by having the five rows of bony plates distinct throughout. Seven species of sturgeons are found in the waters of the United States. First to be mentioned is the common sturgeon, *Acipenser sturio*, which is also found in the seas and rivers of Europe. In the older works it is called *A. oxyrrhynchus*, but the differences between specimens from the two shores of the Atlantic are slight. On our coast it ranges south to Florida. In color it is grayish brown above, silvery on the lower part of the sides, and white beneath. In the European seas this species attains a length of eighteen feet. Next in order comes the *A. transmontanus* of the Pacific coast south to Monterey. It sometimes weighs six hundred pounds. In the Mississippi and its tributaries, as well as in the great lakes, occurs the lake sturgeon, *Acipenser rubicundus*, a much smaller species than the two just mentioned. According to Günther this species is sometimes found on the coast of Europe, but as a rule it does not usually descend to the sea. A large specimen will weigh one hundred pounds.

All of these species, as well as those of Europe to be mentioned below, are used to a varying extent as food, but the green sturgeon (*A. medirostris*) of the Pacific coast, a large species, has the reputation of being poisonous. The sturgeons have mostly a migratory habit like the salmon, ascending the rivers for the purposes of reproduction. At times they are very numerous in the Hudson, and their reddish-colored flesh is in a jocular way spoken of as 'Albany beef.' Still, the flesh of the common sturgeon is not extensively used as food on the Atlantic coast. In the central region *A. rubicundus* is used somewhat more, while the Pacific sturgeon, caught in the Sacramento and Columbia rivers, is brought to market in considerable quantities.

Of the European species, the sterlet (*Acipenser ruthenus*), the bielaga, huso, or hausen (*A. huso*), the common sturgeon (*A. sturio*), and a fourth form, the osseter (*A. güldenstaedtii*), are the best known. Largest of these is the huso of the rivers falling into the Black and Caspian seas, which sometimes reaches a length of twenty or twenty-five feet, and a weight of nearly three thousand pounds. In the early spring, when the ice is still in the rivers, the huso leaves the sea to ascend the streams. Across the Volga and other streams the fishermen drive long stakes leading to a trap, the whole resembling an eel weir on a large scale, except that the apex of the angle is turned up stream. To warn themselves of the approach of the fish, the fishermen suspend bobs in the water, the motion of which is of course an indication of their presence. The sterlet is a much smaller species, only about three feet in length, but it is very highly prized on account of the delicacy of its flesh. In Europe the common sturgeon occurs only in the west, those found in the Thames being regarded as a royal fish and reserved for the table of the sovereign.

Not only is the flesh esteemed a delicacy by many, but from the roes (ovaries) the celebrated caviare is prepared. This can be made from the eggs of any species, but that of the sterlet is the most highly esteemed, and is supplied to the table of the Tzar. The roes are taken from the female fish, washed with vinegar, salted, and dried. Tastes differ as to the palatability of this dish; to some it is a great delicacy, while others regard it in a greatly different esteem. Indeed, the word has passed into a proverb, and through Hamlet, Shakespeare says, "'T was caviare to the general." One

fact may partially account for this difference in tastes. Caviare is not all of equal quality; in some the eggs have reached a greater or less extent of decomposition before drying. The annual amount of caviare put on the market is almost incredible. The Caspian fisheries alone have in one year produced over two hundred tons. The size of the roes is enormous, comprising nearly a third of the weight of a ripe female. Another valuable product of the sturgeon is isinglass, which is merely the dried air bladders. It is prepared by cutting open the bladders and stripping the silvery gelatinous skin from the rest, and drying it.

The ancient Romans highly prized the flesh of the sturgeon, and it figured on the tables at all the great feasts. It cost enormous prices, and Cicero rebuked the epicures for spending such sums on a fish. As a contrast, it might be stated that at the time of writing, a sturgeon sent from Newburyport to Boston could not find a purchaser, no one caring for its flesh.

The only other genus is *Scaphirhynchops*, the shovel-nosed sturgeons, in which no spiracle is present, and which has a flattened spade-like snout, while the bony plates run together on the tail. Four species are known, three from Asia, and one (*S. platyrrhynchus*) from the Mississippi valley, and the western and southern states. It reaches a length of five feet.

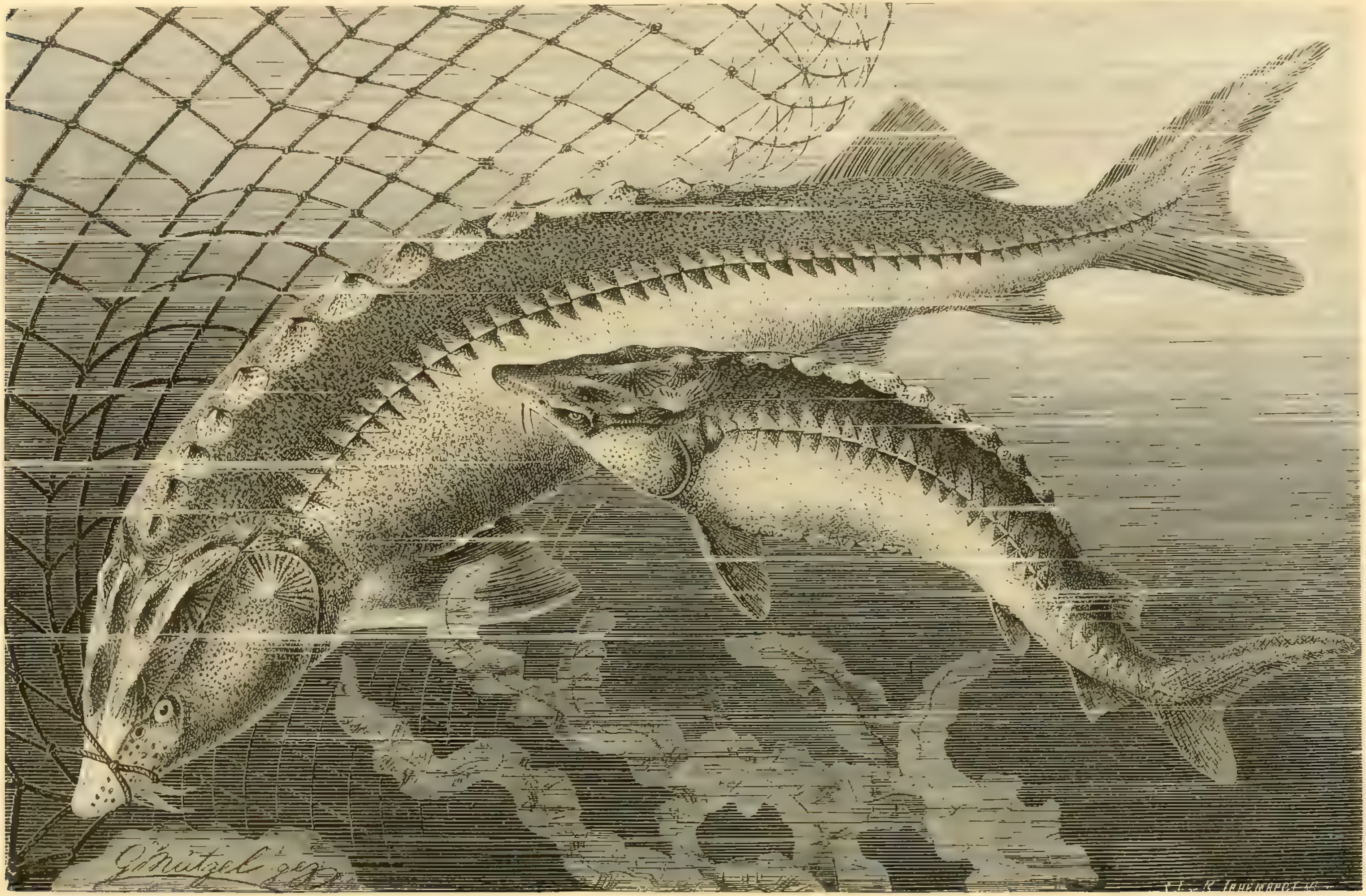
The sturgeons, though without teeth, are carnivorous, feeding mostly on other fishes. Their protrusible mouth and large size renders it an easy task to swallow an ordinary sized fish whole. The development of the sterlet has been followed by Salensky, a Russian naturalist. It follows a type in some respects intermediate between the teleosts and batrachians. A large amount of yolk is present, and on this the young fish lives for three weeks. The segmentation is total but irregular. In the larva, horny teeth are developed on the gums and gill arches, but they disappear after three months. The median fin is at first continuous, but afterwards becomes divided into dorsal, anal, and ventral fins.

The family Polyodontidæ has a distribution like the last. Two genera only are known; one, *Polyodon* (or *Spatularia*) is represented by a single species in North America; the other, *Psephurus*, occurring in China. Both have the body naked, or covered with minute, star-shaped bony plates; the snout is very long and shovel-like, being flattened horizontally, and extending to a long distance beyond the mouth; the mouth is large, and provided with minute teeth in each jaw. These peculiarities are referred to in the name Selachostomi (shark-mouthed) which is sometimes used for the group.

Polyodon spatula is the paddle-fish, spoon-bill cat, or duck-bill cat of the Mississippi valley and the southern states. It has the paddle terminating the snout broad, and forming from a fifth to a third of the total length of the fish, which may reach five or six feet. It frequents the muddy bottoms, stirring up the soft ooze with its paddle, and eating the worms, crustaceans, and other organisms which it contains. *Psephurus* likewise contains but a single species, *P. gladius*, which has been found only in the rivers of China. Its habits are much like those of the paddle-fish, but it is much larger, sometimes reaching a length of eighteen feet. Both genera are confined to fresh water.

Order IV. — PYCNODONTINI.

The Pycnodontini (or Lepidopleurini, as it is sometimes called) is an extinct group whose members ranged from the carboniferous to the early tertiary rocks. These



Acipenser sturio, European sturgeon.

fishes had a short and vertically flattened body, much like that of the chætodonts of the present time, but covered with rhomboid enamelled scales and peculiar dermal ribs (called pleurolepida), which covered either the whole body or only the anterior portion with a sort of lattice-work. The tail was either homocercal or heterocercal. Three families, PLATYSOMIDÆ, PLEUROLEPIDÆ, and PYCNODONTIDÆ, containing numerous genera, have been described, but do not need characterization here. Their geological appearance corresponded with the order in which they are mentioned.

ORDER V. — CROSSOPTERYGII.

Only two living genera, *Polypterus* and *Calamoichthys*, represent this order in the existing seas, but in former times the genera were many; these fossils are now arranged in five families, while the two genera just mentioned constitute the sixth (POLYPTERIDÆ) of the order. All of these forms, recent and fossil, agree in the following characters: the caudal fin is usually diphycercal, the dorsal divided into either two large or many small divisions, the pectorals and ventrals have a scaly axis, and fulcra are absent from all. The throat is protected by two large plates, to which occasionally

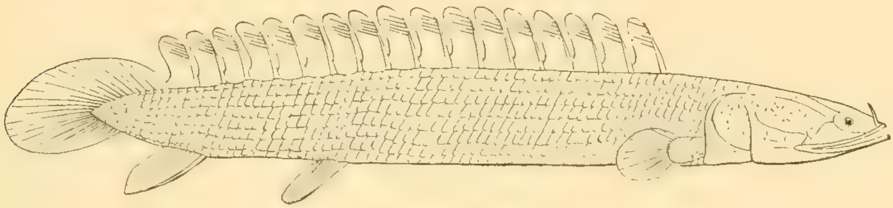


FIG. 68. — *Polypterus bichir*, bichir.

smaller lateral ones are added. The scales covering the body may be either thin and cycloid in character, or thick and rhomboid, like those of most ganoids. Some of the fossil forms, like *Ctenodus* and *Dipterus*, approach the lung-fishes the most closely of any members of the sub-class.

The two living genera, as we have just said, belong to one family. They have rhomboid scales, a long, many-divided, dorsal fin. The mouth is placed at the end of the body, and above it are two barbels. In *Polypterus*, ventral fins placed far back are present, but in the long and slender *Calamoichthys* none are present. The best known species is the bichir (*P. bichir*) of the upper Nile and other African rivers. It reaches a length of about eighteen inches, and is regarded as a valuable food fish, in fact the best that the river affords. In the system of Cuvier, the bichir was placed among the bony fishes, in the vicinity of the herrings. One of the most interesting features connected with the fish is that, in the young, external gills are present. Two other species, *P. senegalensis* and *P. endlicheri*, are known. All live in the deeper pools, and apparently bury themselves in the slime and ooze on the bottom, where they feed on fishes and other aquatic animals. The nasal cavity is very complicated, a labyrinth being formed by five parallel passages, each of which contains a gill-like fold. Nothing similar is known in other fishes. Of

FIG. 69. — Young bichir, showing (*g*) external gill.

the development of the bichir and its allies, we know nothing. The single species of *Calamoichthys*, *C. calabaricus*, as its name indicates, comes from Old Calabar, West Africa.

Order VI. — GINGLYMODI.

The gar-pikes present an approach to the bony fishes in many respects. They have a bony skeleton, the bones of the fins rudimentary, the spiral valve of the intestine poorly developed. The body is covered with closely placed rhomboid scales, and the shingle-like fulcra are present on the fins. The vertebræ are convex in front and concave behind, forming ball and socket joints, the tail heterocercal, and the ventral fins are between the pectorals and anal.

The family Lepidotidæ was almost entirely confined to the mesozoic strata, only

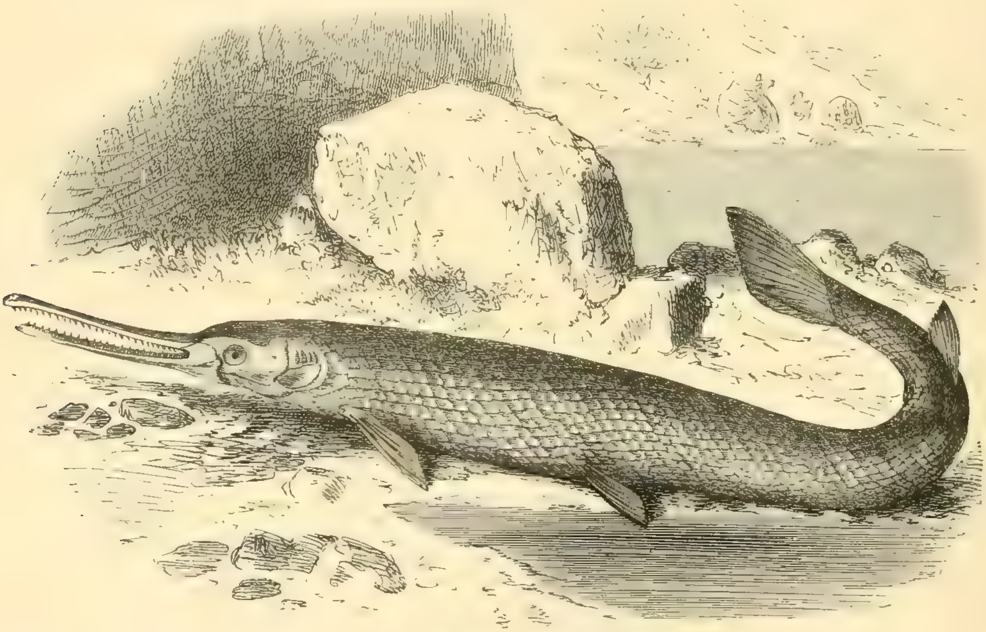


Fig. 70. — *Lepidosteus osseus*, gar-pike.

a few, like *Palæoniscus*, extending back into the carboniferous. The Lepidosteidæ appeared in the Laramie or fresh-water cretaceous, and to-day only three or four species exist, all confined to our continent. The gar-pikes are all long and slender fishes, covered with hard scales laid on in oblique series, forming a very hard armor. The external bones of the skull are hard and roughened, and the beak is long and flattened, the upper jaw being longer than the lower. The dorsal fin is small, and placed very far back upon the body. In the degree of development of the air bladder and the gills, the gar-pikes are very like the lung-fishes. The bladder is divided up into a number of cellular cavities, recalling at once a rudimentary lung, and communicates with the œsophagus by a slit-like glottis. Besides, it receives the blood-vessels from the aorta. Not only is this organ like a lung in structure, but it functions as such to a certain extent. Two genera of gar-pikes have been indicated, *Lepidosteus* and *Litholepis*, but their distinctness is questioned. The most common species is the common gar-pike, or, as it is frequently

called, the long-nosed gar or the bill-fish, *Lepidosteus osseus*. This species is widely distributed throughout the United States in lakes and rivers from Lake Champlain to Texas. It reaches a length of about five feet. Its development has been studied by Alexander Agassiz, Balfour, and Parker, and Dr. E. L. Mark, though the latter has not, at the time of writing, published his results. The fish are nocturnal in their habits, and in the nights of the last of May and the first of June they approach the shallow water in large numbers for the purpose of laying their eggs. These eggs are covered with a very sticky envelope of complicated structure, which immediately adheres to any object with which it is brought in contact. In its development it is much like the bony fishes. When it hatches from the egg it has a very large mouth with a row of suckers above. By the aid of these it attaches itself to submerged stones. Now the fins begin to appear, and in the space of two or three weeks the suckers disappear, and the young gar-pike swims freely.

The broad-nosed gar-pike, *L. platystomus*, is smaller than the preceding, and is rather more southern in its range, while the alligator gar, *L. tristœchus*, is a much larger form, reaching a length of eight or ten feet. It lives in the rivers of the southern states, and extends south to Central America, and across into some of the West India Islands. This is made the type of a distinct genus, *Atractosteus*, on account of two rows of teeth in the jaws.

Order VII. — HALECOMORPHI.

This order and the last are frequently united as members of a group known as Holostei, which, besides the ossified skeleton; have several other structural features in common. The only living genus is *Amia*, the type of the family Amiidæ. *Amia* is even more closely related to the bony fishes than are the gar-pikes. It is covered with large, round scales, lacks the shingle-like fulcra on the fins, and has the vertebræ concave at both ends, as in the teleosts. These points, together with other superficial ones of minor importance, give the bow-fin a herring-like appearance, and formerly led to the classification among the clupeoids. The ordinal name, Halecomorphi, also refers to this appearance, and means shad-like. *Amia calva*, the bow-fin, mud-fish, dog-fish, brindle, grindle, 'John A. Grindle,' or lawyer, as it is variously termed, is the only known species. In color it is dark olive or blackish above, and faintly marked with dark on the lighter sides. The sexes can readily be separated by a round black spot, ringed with lighter orange or yellow at the base of the caudal fin of the male, which is lacking in the female. A difference is also noticeable in size, the female reaching a length of two feet or more, the male but rarely exceeding eighteen inches. As in the gar-pikes, the air bladder of the bow-fin is cellular and functions as a lung. On the mode of respiration in both genera, Dr. B. G. Wilder has made some interesting observations. Before his experiments it had frequently been noticed that the gar-pike rises at intervals to the surface of the water, emitting at each time several bubbles of air, but whether air was taken in was not certain, though from the amount exhaled this seemed probable. Dr. Wilder took an adult bow-fin, which was kept in an aquarium, and gradually accustomed it to being handled.

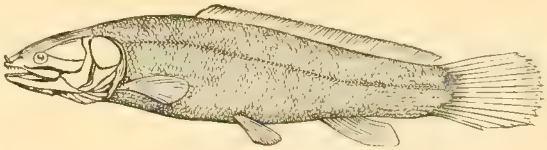


Fig. 71. — *Amia calva*, bow-fin.

"After a time it would swim slowly in the tank with no apparent agitation on account of the contact, and come to the surface at the usual intervals to discharge a bubble of air. Having been thus prepared, the fish was permitted to move to and fro at about six inches below the surface, but was prevented from rising. It became uneasy, and, after a few not very violent efforts to disengage itself, emitted a large bubble of air, which rose to the surface.

"If this emission were all it required, we may suppose that it would have been content. On the contrary, after a second or two of quiet (perhaps resulting from the habit of being satisfied after the respiratory action), the fish became more and more uneasy, moved rapidly to and fro, turned and twisted, and lashed with its tail, and finally escaped from the hand. It rose at once to the surface, and, without emitting any bubble whatever, opened the jaws widely, and apparently gulped in a large quantity of air. It then descended, and remained quiet for the usual interval. This experiment was several times repeated, always with the same result."

To the physiologist these experiments are highly interesting, for here we see the early stages of the change from an air bladder to the lungs of the higher vertebrates. In the lung-fishes this change of function is carried to a greater extent. The morphologist is also interested in the gradual development of a lung-like organ, and the transference of its duct from the dorsal side of the œsophagus in the fishes to the ventral position which it occupies in the higher vertebrates, including the Dipnoans.

The bow-fin belongs exclusively in fresh water, preferring the still waters of lakes and sluggish rivers. It ranges from Minnesota south to Florida and Texas. It is very voracious, and eats large numbers of other aquatic animals, but its "flesh is peculiarly soft and pasty, and is of no value for food." Its eggs are moderate in size, and are enveloped in an outer covering, which in structure is much like that found in *Lepidosteus*. Nothing is known of the development, and the students in the interior of our country have here a fine chance to do good work.

The fossil genera *Notæus* and *Amiopsis*, of the tertiary rocks, are closely allied to *Amia*. Frequently associated with this genus are the fossil families Leptolepidæ, Caturidæ, and Platyuridæ, but these may possibly belong near the salmons and clupeoids, and may be the oldest physostomous fishes. They appear in rocks of the Jurassic age, and appear to have held their position here through a dictum of Agassiz, that any fish from a formation older than the cretaceous must be a ganoid.

In conclusion, we may say that the group of ganoids appears to be an artificial one, and will probably be divided up (this has been done by some, notably Professor Cope), some of its members being accorded a distinct rank, while others may be placed among the forms here treated of as teleosts. This will probably be the case with the Lepidotidæ, which on many accounts appear to belong to the Isospondyli, and to be primitive forms of clupeoid and salmonoid fishes. *Pterichthys*, again, is a problematical form, and probably has nothing to do with the group with which it is usually associated, but may be, according to Professor Cope, either a modified ascidian related to *Chelyosoma*, or is one of the Acrania directly descended from such a type.

J. S. KINGSLEY.

SUB-CLASS II. — TELEOSTEI.

Next after the ganoids come the vast majority of living fishes. It is generally admitted that the gradation of the ganoids into the teleostean hosts is evident, and

that, on the one hand, the Amiids are the most teleostean (or like the ordinary fishes) of the ganoids, and, on the other, such forms as the Albulids and Elopids are the most ganoid-looking of the teleosts. The succession from those forms is tolerably straight in their various ramifications to the ends of the different series. But there are several types that break into the continuity of the series, and are a source of trouble and perplexity to the systematist. These are the Nematognaths, the several types of apodal fishes, and the small group of Opisthomes, including the two families, Notacanthidæ and Mastacembelidæ. The genetic relations of none of these are fully understood. By several authors — among them Agassiz and Cope especially — the group of Nematognaths, or catfishes and their relations, has been regarded as most nearly related to the sturgeons, and by Cope it is imagined that "future discoveries will prove that it has been derived from that division by descent." To others this relationship is not perfectly clear. The Nematognaths are, however, doubtless modified from a primitive type not in line with the majority of existing fishes, and it will be convenient to consider them among the first, although not the very first. There are the various eel-like forms, whose relations are as little, if not still less, understood than those of the Nematognaths. It is evident, however, that the eels have sprung from a generalized type, and apparently also from a stock out of the line of the typical fishes, although, perhaps, from a more recent type than the ancestors of the catfishes. Nevertheless, it will interfere less with a serial arrangement if we commence with the eel-like forms and consider their ramifications, after which we may take up the Nematognaths and their kindred, and finally the more typical teleosts.

Teleosts are those fishes which are predominant in the present epoch of our globe, and which are mostly characterized by a well-ossified skeleton; and in allusion to this feature the sub-class name has been given (*teleios*, perfect, *osteon*, bone). The skeleton, however, is as much ossified in certain Ganoids (*Lepidosteus* and *Amia*) as in some Teleosts, and consequently we have to study other parts of the organization to learn whether the group is a natural one. As a result of such study, it has been found that there is a considerable departure in the brain, and especially the optic nerves, as well as in the heart, from the types heretofore considered. Without going into details, we may state that the optic nerves simply decussate or cross each other without any blending of fibres or chiasma, as in the Ganoids, and the heart has in front an arterial bulb, which has generally only a pair of opposite valves. With these characters as key-notes, we can co-ordinate others, and convince ourselves that the Teleosts have developed through an essentially continuous though perhaps composite line from a Ganoid stock; for, diversified as they are, the capital characters differentiating subdivisions are few, and the intergradation manifest. It is indeed a difficult matter to find gaps of demarcation. For many years the grouping sanctioned by Johannes Müller has been a popular one. In this the Lophobranchiates and Plectognaths were set apart, and all the rest were classified as Physostomes and Physoclists, some dividing the latter into 'orders,' designated as Acanthopteri, Pharyngognathi, and Anacanthini, while others grouped them together. This arrangement, however, was a very artificial as well as a very superficial one, for unlike forms were united while like ones were with equal violence divorced. There was, nevertheless, a shade of reason in the grouping. The Physostomes were those Teleosts whose air-bladder communicates with the œsophagus by a tube or mouth (*phusa*, bladder, *stoma*, mouth), while in the Physoclists the air-bladder is shut off from all communication with the outer world (*phusa*, bladder, and *kleistos*, closed). But even the availability of these characters

sometimes fails, for the Physoclists in very early life have a communication between the bladder and intestine, and such communication is liable to be persistent in a few adults. For this very reason, however, the character in question becomes important for another purpose, — to determine the order of succession of the respective types. Inasmuch as the Ganoids had and have a similar connection between the air-bladder and intestine, it might reasonably be assumed that the physostomous fishes are nearer the progenitors of the Teleostean stock than the physoclistous ones. Such assumption, moreover, has been verified by a consideration of all other parts, and it is now generally admitted that next after the Ganoids should come Physostomes; but which special group or sub-division it should be is a question more difficult to answer. As already indicated, we shall commence with the eels, but without pretending that they are the most generalized. We must, on the contrary, admit that in some respects they are much more specialized than those which are to follow. It is therefore simply and purely from motives of convenience, and to render future breaks less numerous and abrupt than they would otherwise be, that we adopt the sequence of forms here to be followed. Modified as they are, they nevertheless retain more of the evidences of genetic relations to primitive types than do the highly specialized forms into which the typical fishes grade and culminate.

Order I. — SYMBRANCHIA.

Before proceeding to the consideration of the typical eels, it will be well to notice a few fishes which are eel-like in habit, and even still more elongated than the common eels, but which in other respects are more like the general stock of fishes. The forms exemplifying this group, which has been called Symbranchia, have been ranged by Professor Cope under two orders, the Ichthyocephali and Holostomi. Both agree in the development of special intermaxillary bones and the position of the supramaxillary behind and parallel to them, but disagree in the development of the shoulder girdle, some (Monopteridæ) having the girdle directly connected with the skull, while others (Amphipnoidæ) have no osseous junction. The palatine bones are well developed and even very broad, being thus quite unlike those of the true eels. Although the species are few, they exhibit such differences of structure as to demand the recognition of four families, the Monopteridæ, Symbranchidæ, Amphipnoidæ, and Chilobranchidæ. The first three are remarkable for an excessive elongation of the abdominal portion, and the approximation of the anus to the tail end rather than the head. The *Monopterus javanensis* has as many as one hundred abdominal and eighty-eight caudal vertebræ; on the other hand, the Chilobranchidæ (a family of doubtful relationship) have only about twenty-one abdominal and fifty-two caudal vertebræ. The monotypic Monopteridæ and Amphipnoidæ inhabit the East Indian seas; the Symbranchidæ are, partially at least, fresh-water fishes, of which two species are East Indian and one South American. The two known species of the Chilobranchidæ are Australasian. The Monopteridæ and Amphipnoidæ especially exhibit interesting modifications of their branchial and respiratory apparatus.

Order II. — APODES.

The common fresh-water and sea eels are the typical representatives of an order which has been called Apodes, in that they are the best-known examples of the group,

and those which the mind of the American or European pictures to itself in connection with the name. But those common species exhibit structural features from which most of the order deviate, and they at the same time depart less from the characteristics of ordinary fishes than do most of their associates. Their bones are developed in greater number than in most of their relations, and there is a nearer approach in the osseous frame-work generally to the typical fishes. The congers, or conger-eels, are, however, as little aberrant as the true eels. But, with these exceptions, the species of the order generally to be met with exhibit remarkable modifications of structure, and a notable reduction of the bones of the sides of the head. So great, indeed, are the differences to be seen on a comparison of the true Apodal or eel-like forms, that they have been distributed by an eminent authority (Professor Cope) between two orders, the Enchelycephali (eels and congers), and the Colocephali (Muræenids, etc.). Other forms have been associated with the eels, but with little reason. Few nowadays would consider the electrical eel to be closely related to the true eels, and therefore few would dissent from excluding it from the order Apodes, if intended to be grouped primarily around the common eel. There are also quite good grounds for the refusal to admit the Monopterids and Symbranchids in the same natural order as the Anguillids, but the differences between the last-named fishes and the Muræenids appear to be of less value, and gradations exist between them. For the present at least, therefore, all such may be retained in a common order under the name Apodes.

The Apodes may then be defined as teleost fishes with the ethmoid and vomer coalesced and constituting the front of the upper jaw, the supramaxillaries entirely lateral, and the intermaxillaries obsolete or wanting, the palato-pterygoid arch more or less imperfect, the cranium with a single condyle (the basioccipital) for articulation with the backbone, the branchiostegals well developed, and the form elongate and serpentiform.

The fishes in which these characters are manifested are all elongated, and the form may consequently be used for the definition of the group. Nevertheless, it must not be forgotten that form is an extremely variable element in some orders, and even in the present the eel-like appearance is not invariably a striking feature. The curious *Simenchelys*, for instance, was not at first recognized as an eel by the ichthyologists into whose hands it fell, and it was only when the structure of the mouth parts was examined that its position became evident. On the whole, however, there is a very considerable likeness between the various constituents of the order, so far, at least, as general form is concerned. The skeletal and other differences are better marked, and apparently justify the recognition of several families.

The ANGUILLIDÆ, or typical eels, have the ethmo-vomerine region moderately broad and extended backwards, the jaws rather elongated and narrowed forwards, the opercular bones all existent, the pterygoid bones reduced and slender, the tongue free in front, the nostrils moderately distant and lateral, the caudal fin developed and confluent with the dorsal and anal, the dorsal remote from the head, and pectorals present. Scales are present, of small size and elliptical form, obliquely set, more or less separated from each other, and tending in opposite directions, or at right angles to each other. But one genus of the family thus defined has been recognized, the genus *Anguilla*. The species have not been determined with certainty, some naturalists having recognized as many as forty-nine species (Kaup), another (Günther) about twenty-five species, while a more recent student (Dareste) has thought that not more than four valid species can be discriminated. The four recognized by Dareste

are *A. vulgaris* (arctogæan), *A. marmorata* and *A. mona* (Indian Ocean), and *A. megalostoma* (Oceanica).

Eel is the name by which the species of *Anguilla* are known to all English-speaking peoples, and only where peculiar marine forms of the order are very abundant are the representatives of the genus designated by any qualifying term, such as the fresh-water eel. Local synonyms are unusually few, at least outside of England.

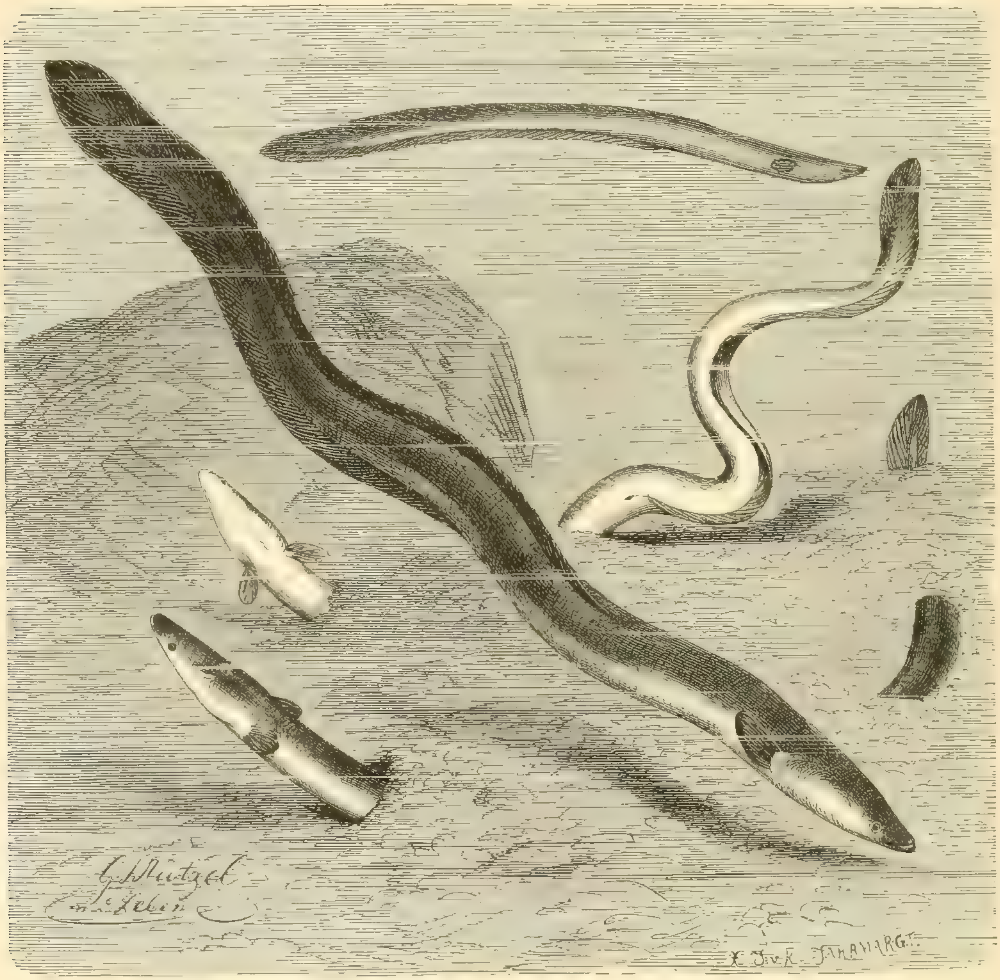


FIG. 72. — *Anguilla vulgaris*, eel.

Species of the genus are very widely but not universally distributed. In the United States they are found in almost all streams of the eastern slope of the continent having uninterrupted communication with the ocean, but were originally wanting in the great lakes above Niagara, as well as along the Pacific coast. The significance of some of these facts will soon appear. While occurring in fresh water, the same species are also found in salt water. Furthermore, in certain seasons of the year very young eels may be seen ascending the streams, and evidently having come from the salt water, where they must have been born. In some streams such young eels are

found in almost incredible numbers, and the concourses are known in England as 'eel-fairs.' Ordinary obstacles may be overcome, and rapids of considerable slope may be surmounted or evaded, but very high falls and precipitous banks arrest progress. As already intimated, Niagara Falls is a barrier to their upward course, but, in the words of Professor Baird, "in the spring and summer the visitor who enters under the sheet of water at the foot of the falls will be astonished at the enormous numbers of young eels crawling over the slippery rocks and squirming in the seething whirlpools. An estimate of hundreds of wagon-loads, as seen in the course of the perilous journey referred to, would hardly be considered excessive by those who have visited the spot at a suitable season of the year." At other times large eels may be seen on their way down stream, although naturally they are not as conspicuous then as are the hosts of the young on their way up stream. Nevertheless, it is now a well-assured fact that the eels are catadromous, that is, that the old descend the watercourses to the salt water to spawn, and the young, at least of the female sex, ascend them to enjoy life in the fresh water.

The generation of the eel was long involved in great mystery, and the knowledge thereof is one of the recent acquisitions of scientific investigation. So late, indeed, as 1880 it was declared by Dr. Günther that "their mode of propagation is still unknown." In want of positive knowledge, the rein has been given to loose hypothesis and conjecture. It has been variously asserted that eels were generated from slime, from dew, and from the skins of old eels or of snakes. The statement that they come from horse-hairs is familiar to many country boys, and the origin of this belief is due simply to the fact that there are certain aquatic worms, known under the generic name *Gordius*, which are elongated and apparently smooth like the eel, and which may be found in the same waters. It was one of the ideas of the Greeks to attribute their paternity, as of many other doubtful offspring, to the convenient Jupiter. The statement that they are viviparous has arisen from two causes, one the existence of intestinal worms, and the other from the confusion of the eel with an elongated, and consequently eel-like, but otherwise very different form, the *Zoarces viviparus*. The *Zoarces* is, indeed, in Germany as well as in the Scandinavian countries, generally known as the Aal-mutter, or eel-mother, and thus in its name perpetuates the fancy. Even where eels are to be found in extreme abundance, and where they are the objects of a special culture, like erroneous opinions prevail. Thus, according to Jacoby, about the lagoon of Comacchio, there is an "ineradicable belief among the fishermen that the eel is born of other fishes; they point to special differences in color, and especially in the common mullet, *Mugil cephalus*, as the causes of variation in color and form among eels. It is a very ancient belief, widely prevalent to the present day, that eels pair with water-snakes. In Sardinia the fishermen cling to the belief that a certain beetle, the so-called water-beetle, *Dytiscus rœselii*, is the progenitor of eels, and they therefore call this 'mother of eels.'" The assignment of such maternity to the water-beetle is doubtless due to the detection of the hair-worm, or *Gordius*, in the insect by sharp sighted but unscientific observers, and, inasmuch as the beetle inhabits the same waters as the eel, a very illogical deduction has led to connect the two together.

All such beliefs as have been thus recounted are due to the inconspicuous nature of the generative organs in eels found in fresh waters and at most seasons — a characteristic which is in strong contrast to the development of corresponding parts in fishes generally. Nevertheless, the ovaries of the eel were discovered, as long ago as 1707, by Dr. Sancassini, of Comacchio, and described by the celebrated Valisneri (after whom the

plant *Valisneria* was named) in 1710, again by Mondini in 1777, and almost contemporaneously by O. J. Müller, of Denmark. Later, the illustrious Rathke (in 1824, 1838, and 1850) and also Hornbaum-Hornschuch published the results of special investigations, and figured the eggs. But it was only in 1873 (after several futile endeavors by others) that the male organ of the eel was recognized, also by an Italian naturalist, Dr. Syrski, in small individuals of the species, and a previous idea that the eel was hermaphroditic thereby dispelled. The sexual differences are correlated with external ones, and generally the males and females, when adult, can be told apart. Jacoby testifies that he examined large numbers with a view to solve this question. The most important differences relate to (1) size, (2) form of the snout, (3) color, (4) dorsal fin, and (5) size of the eyes. (1) The males rarely attain a length of more than seventeen to nineteen inches, while adult females are generally much larger; (2) the snout in the male is attenuated and rather pointed, while in the female it is comparatively broad and blunt; (3) the male is a deep darkish green, or often a deep black with a shining lustre, and a whitish belly, while the female has a clearer color, usually of a greenish hue on the back and yellowish on the belly; (4) the dorsal fin is lower and less developed in the male than in the female; and (5) the eye of the male is large, and that of the female, as a rule, comparatively small. These characters, however, do not always hold good. Jacoby remarked that "special reference having been paid to the height and narrowness of the dorsal fin, much success has been met with in picking out, in the fish-market of Trieste, the eels which possessed the organ of Syrski [that is, the male organ]; absolute certainty in recognizing them, however, cannot be guaranteed. If one is searching among living eels with no characters in mind, — with the exception of the first, that of length, — he will find in every ten eels, on an average, eight females and two with the supposed male organ; but, if the selection is made with a careful reference to all these marks of difference, the proportion changes, and out of every ten examples about eight will be found with the supposed male organ."

According to Herr Benecke, "it may be assumed with the greatest safety that the eel lays its eggs like most other fish, and that, like the lamprey, it only spawns once and then dies. All the eggs of a female eel show the same degree of maturity, while in the fish which spawn every year, besides the large eggs which are ready to be deposited at the next spawning period, there exist very many of much smaller size, which are destined to mature hereafter and be deposited in other years. It is very hard to understand how young eels could find room in the body of their mother if they were retained until they had gained any considerable size. The eel embryo can live and grow for a long time supported by the little yolk, but, when this is done, it can only obtain food outside of the body of its mother. The following circumstances lead us to believe that the spawning of the eel takes place only in the sea: (1) that the male eel is found only in the sea or brackish water, while female eels yearly undertake a pilgrimage from the inland waters to the sea, a circumstance which has been known since the time of Aristotle, and upon the knowledge of which the principal capture of eels by the use of fixed apparatus is dependent; (2) that the young eels, with the greatest regularity, ascend from the sea into the rivers and lakes.

"All statements in opposition to this theory are untenable, since the young eels never find their way into land-locked ponds in the course of their wanderings, while eels planted in such isolated bodies of water thrive and grow rapidly, but never increase in numbers. Another still more convincing argument is the fact that in lakes which formerly contained many eels, but which, by the erection of impassable weirs,

have been cut off from the sea, the supply of eels has diminished, and after a time only scattering individuals, old and of great size, are taken in them. An instance of this sort occurred in Lake Muskengorf, in West Prussia. If an instance of the reproduction of the eel in fresh water could be found, such occurrences as these would be quite inexplicable.

"In the upper stretches of long rivers the migration of the eels begins in April or May; in their lower stretches and shorter streams, later in the season. In all running waters the eel fishery depends upon the downward migrations; the eels press up the streams with occasional halts, remaining here and there for short periods, but always make their way above. They appear to make the most progress during dark nights, when the water is troubled and stormy, for at this time they are captured in the greatest numbers. It is probable that after the eels have once returned to the sea and there deposited their spawn, they never can return into fresh water, but remain there to die. A great migration of grown eels in spring or summer has never been reported, and it appears certain that all the female eels which have once found their way to the sea are lost to the fisherman."

Eels, in the words of Mr. W. Ballou, are "among the most voracious of carnivorous fishes. They eat most inland fishes, except the gar-fish and the chub. Investigation of six hundred stomachs by Oswego fishermen showed that the latter bony fish never had a place on their bill of fare. They are particularly fond of game fishes, and show the delicate taste of a connoisseur in their selection from choice trout, bass, pickerel, and shad. They fear not to attack any object when disposed, and their bite in human flesh shows even a vicious attitude towards man. On their hunting excursions they overturn huge and small stones alike, working for hours if necessary, beneath which they find species of shrimp and crayfish, of which they are exceedingly fond. Of shrimps they devour vast numbers. Their noses are poked into every imaginable hole in their search for food, to the terror of innumerable small fishes."

In the opinion of Mr. Ballou, too, "eels are to the water what the fish-hawk is to the air. They are, perhaps, the most powerful and rapid of natatorians. Again, they hide in the mud beneath some log or overhanging rock, and dart out with tremendous fury at the unsuspecting prey. They attack the spawn of other fishes open-mouthed, and are even said to suck the eggs from an impaled female. They fearlessly and rapidly dive head foremost in the mud, disappearing from view in the twinkling of a star. They are owl-like in their habits, committing many of their depredations at night.

"No fish is yet reported to utilize a full-grown eel as food. Pickerel, gar-fish, and bass, which are particularly numerous in these lakes, are supposed to literally devour the young fry. Mr. Sawyer describes the operation of the pickerel darting through a long column of young eels, open-mouthed, and devouring vast numbers of them."

The CONGRIDÆ, otherwise named congers or sea eels, are closely related to the Anguillidæ, and also have a moderately extended ethmo-vomerine region, moderately elongate and attenuated jaws, and well developed opercular apparatus, but the pterygoid bones are better developed and almost perfect in front, and the dorsal commences close behind the head. No scales exist in any of the known species. Several genera have been associated with the typical conger as representatives of the same family. That exemplified by the common conger is, however, the only one common to the northern temperate seas. No specific differences have been discovered between the forms living on the eastern and those found on the western sides of the Atlantic.

Naturalists are divided as to the name it should bear. *Conger vulgaris* is that which has been chiefly used, but several names had been earlier given. The earliest generic name is the expression of a peculiar phase of development. As long ago as 1754, a learned Dutch naturalist, Gronow or Gronovius, proposed a new generic name for a small fish of an elongated form, but much compressed, and in life transparent. This was found to be destitute of generative organs, and was regarded by Professor Carus as probably the young of some ribbon-shaped fish. The relations of the fish were later shown by Gill to be rather with the conger, and *Leptocephalus morrisii* was indicated as the young of the common conger. This stage has been considered to be per-

FIG. 73.—*Conger vulgaris*, conger eel.

sistent under certain conditions, and its further development to be arrested, but whether such is the case or not remains to be proved. There seems to be a tendency in the congers to fail in the complete ossification of the skeleton, for Dr. Dareste has found instances of such failure to ossify, or *rachitis*, "in a large number of specimens;" he prepared the skeleton of "a conger of medium size," the bones of which were "flexible," and had remained in "an entirely cartilaginous state."

The conger attains about twice the size of the common eel, and "individuals of six feet in length are not rare." It is distinguished from the common eel, in addition to the characters already indicated, by the uniserial and paling-like teeth (which are close set, and constitute an incisorial margin), as well as by color; the dorsal region is dark and the lower soiled white, the pores of the lateral line whitish, the dorsal and anal

fins generally pale with a black margin, and the pectorals dusky, margined with lighter.

The sexual organs of the conger are much more conspicuous than those of the common eel, and, indeed, the female has sometimes an exuberant supply of eggs, and almost bursts on account of them. Dr. Hermes relates, in fact, that a female in the Frankfort aquarium did actually "burst on account of the extraordinary development of the ovaries:" the conger in question weighed twenty-two and a half pounds, and the ovaries eight pounds; it was calculated that there were 3,300,000 eggs. The eggs are larger than those of the eel, having a diameter of about a third of a millimetre, while those of the eel are only about a fifth to a fourth of a millimetre in thickness. Except in relative development, however, the sexual organs of the two forms are essentially alike. As in the eel, the sexes are as a rule externally distinguishable, and the male is considerably smaller than the female.

The conger is a strictly marine fish, and does not ascend rivers like the eel; it also prefers rather deep water, and, although abundant in the British waters and a very common market fish, it is rare on the American, or at least rarely taken by the fishermen or brought to market.

A strange eel, found only in deep water, and named by the fishermen the pug-nose eel, and by naturalists *Simenchelys parasiticus*, is related to the true eels, but has been set apart as the type of a peculiar family, the SIMENCHELYIDÆ. It has most of the osteological characters of the preceding, but the front, instead of being narrow and attenuated, is blunt and rounded, whence the names given to it. It has scales like those of the common eel. Many individuals have been obtained attached to the halibut, into whose flesh they had burrowed. Specimens have as yet only been found on off-shore banks south of Newfoundland.

The OPHICHTHYIDÆ form another family of eels quite well represented in the extreme southern waters bounding the United States; they may be readily recognized by the peculiar situation of the nostrils, which perforate the margin or even inner sides of the lips. Species of several genera (*Ophichthys*, *Ophisnerus*, *Callechelys*, and *Letharchus*) have been found around Florida, and of another (*Myrichthys*) on the Pacific coast.

A family abounding in species in all tropical seas is that of the MURÆNIDÆ. These are remarkable for the rudimentary condition of the palato-pterygoid arch and opercular bones, as well as for the lateral extension of the ethmo-vomerine elements, and the consequent removal backwards of the upper jaw-bones; the branchial skeleton is also much reduced; pectoral fins are generally absent. Most of the species have formidable sharp teeth, and are quite vicious in their habits, biting severely, and capable of inflicting terrible wounds on an incautious assailant. One species is found in the Mediterranean, the common murry or *Muræna helena*; and an anecdote, in which Vedius Pollio was punished for ordering an offending slave to be thrown to the Murænas, is familiar to most lovers of classical history. Five species of the family have been taken in the sub-tropical American waters.

Another family, the MORINGUIDÆ, is related to the Murænidæ, but is distinguished by some remarkable modifications of structure. The pterygo-palatine arch is imperfect, as is also the opercular apparatus, according to Professor Cope, but the form is distinguished by the elongation of the abdominal portion, the caudal portion being shorter, and, above all, the heart is peculiar in being far behind the branchiæ. The species are all inhabitants of the Oriental seas; they are snake-like, or, as the name of

one of the species (*Moringua lumbricoides*) implies, worm-like in appearance and almost destitute of fins, the vertical fins being sometimes reduced to a fold around the end of the tail.

A group of very strange fishes, characterized by elongated jaws, sometimes excessively produced and attenuated, has been generally approximated to the eels. These form the family NEMICHTHYIDÆ. They are chiefly inhabitants of deep seas, although a couple of the species have been caught at the surface, perhaps on account of accident. The most common (but still rare) form has been called *Nemichthys scolopaceus*, the

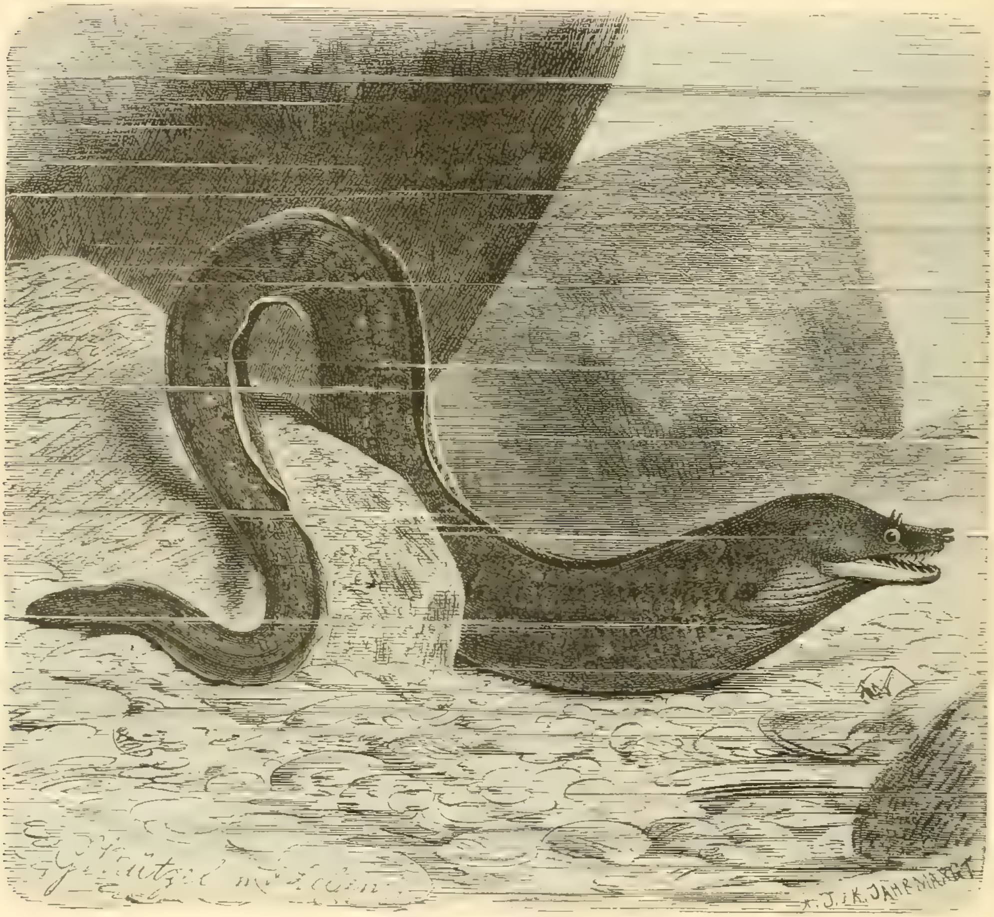


FIG. 74. — *Muræna helena*, muiry.

snipe-like thread-fish, or, popularly, snipe-fish. Three peculiar generic types were lately obtained through the dredgings of the U. S. Fish Commission steamer 'Albatross.' They exhibited a considerable range of variation in dentition.

The only other family that demands notice here is that of the SYNAPHOBRANCHIDÆ. These are deep-sea fishes, of a nearly normal eel-like form, but distinguished by the confluence of the branchial apertures into a single slit below the throat. They have scales resembling those of the Anguillids. The species are inhabitants of the deep seas, and two have been discovered in the depths near the New England coast, *Synaphobranchus pinnatus* and *Histiobranchus infernalis*.

Order III. — LYOMERI.

In the line of specialization of the eel-like forms, we now come to a group of the most extraordinary development. There is a "looseness" about them which has given a name to the order — Lyomeri. The branchial arches are reduced to very simple bars, five in number, on the sides of the œsophagus, and have no connection with the cranium; the supramaxillary bones alone are developed, and have a ligamentous connection with the cranium; the palato-pterygoid arch is entirely wanting; and the suspensorium for the lower jaw is composed of only two pieces, the hyomandibular and quadrate, of an elongate, subcylindrical form, and connected with the skull by a movable joint which allows it to be swung in various directions. Two families of the order have been discovered, the Eurypharyngidæ and Saccopharyngidæ.

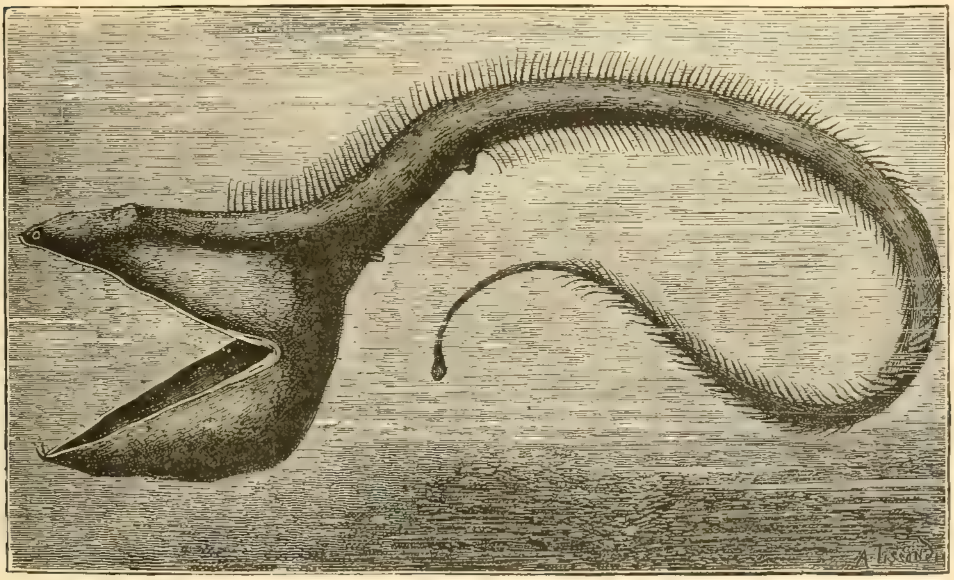


Fig. 75. — *Eurypharynx pelecanoides*, pelican fish.

The Eurypharyngidæ were unknown till 1882. In the last month of that year the French naturalist Vaillant described a species as *Eurypharynx pelecanoides*, and the next year another was made known by Gill and Ryder under the name *Gastrostomus bairdii*. These fishes inhabit the deep sea, and are especially remarkable for the excessive development of the jaws and the oral parts generally. The jaws of *Gastrostomus* are six or seven times as long as the flat squarish cranium, and the intramandibular pouch has the resemblance to that of the pelican which induced Vaillant to give the name *pelecanoides* (pelican-like) to the fish he described. Of course nothing is known, from observation, of its habits, but it is probable that the fish swims considerably over the bottom, and that it feeds with open mouth, taking in the water and contained organisms, and keeping the latter in by the interlocking teeth, which would apparently act like the whalebone of the mysticete whales. Its principal food is doubtless the small animals swimming at large in the horizon it inhabits, — crustaceans, foramenifers, etc. It is not at all likely that it troubles fishes approximating it in size.

The SACCOPHARYNGIDÆ have been long but very imperfectly known. The typical form was first described by an American naturalist, Dr. S. L. Mitchill, of New York, in 1824. The only specimens that have been thus far obtained have been found at the surface, gorged with fishes larger than themselves. They thus contrast, as to their habits, with the Eurypharyngidæ, and their structure would at once indicate a difference of habits. They have, like their kindred, a small head and elongated jaws, but the elongation is quite moderate compared with those of the Eurypharyngids. They have also large raptorial teeth in one or both jaws, well fitted for seizing and holding prey.

Both of the types of lyomerous fishes have very peculiar pedunculated appendages in the place of the lateral line. Their entire organization, in fact, is peculiar to the extent of anomaly, and our old conceptions of the characteristics of the fish class require to be modified in the light of our knowledge of such strange beings.

ORDER IV. — OPISTHOMI.

For want of a better place, we have next to consider another singular group of fishes, whose members have been widely separated in the system. For example, Dr. Günther associated one family (the Mastacembelidæ) with the Blennies in the 'tenth division' of the 'Acanthopterygii,' and isolated another (the Notacanthidæ) in a peculiar group, the 'nineteenth division' of the 'Acanthopterygii.' Professor Cope distinguished the Notacanthids as a peculiar order (Opisthomi) of physoclistous fishes, and ignored the Mastacembelids. The two families, however, appear to be related, and may both be referred to the same order.

The Opisthomes are teleosts with the jaws complete and differentiated, the scapular arch not connected with the cranium but suspended to the vertebral column, the back armed with numerous spines, and with ventrals abdominal or suppressed.

The MASTACEMBELIDÆ have an elongate, eel-like body, a produced lower jaw, the dorsal very long and mostly composed of short free spines, but with a small rayed portion behind, the anal elongated and with about three spines in front, and without ventral fins. The species are inhabitants of the fresh waters of the East Indies and neighboring parts of Asia.

The NOTACANTHIDÆ are also elongate fishes, the spines of the back are short and free, and behind them is one soft ray, or perhaps none; the anal is very long, and chiefly composed of rays, and abdominal ventrals exist which have each several inarticulate and more than five branched rays. The species are marine, and live generally in cold water of considerable or even great depths.

THEODORE GILL.

ORDER V. — NEMATOGNATHI.

The fishes of this order agree in having the maxillary bone imperfectly developed and forming the basis of a long fleshy feeler or barbel. This character has suggested the name Nematognathi, given to the order by Dr. Gill. The analogy of these barbels to the whiskers of a cat has given rise to the vernacular name of cat-fish, by which the members of the order are known in the United States. Other external characters of importance, distinguishing them from the great body of teleostean fishes, are the absence of the suboperclc, and the absence of true scales, the skin being

either naked or more or less covered with bony plates. The anterior vertebræ are coalescent, as in the cyprinoid fishes, and the air-bladder communicates with the organ of hearing by means of auditory ossicles. The bones of the skull are grown together in a greater degree than in ordinary fishes, and the brain is somewhat different, the cerebrum being (in some species, at least) rather better developed, and showing a rudiment of the Sylvian fissure.

The chief osteological character of the Nematognathi are thus summed up by Professor Cope: "Parietals and supraoccipital confluent, four anterior vertebræ co-ossified, and with ossicula auditus. No mesopterygium. Basis cranii and pterotic bone simple; no coronoid bone. Third superior pharyngeal bone wanting, or small and resting on the fourth; second directed backwards. One or two pairs basal branchihyals: two pairs branchihyals. Suboperculum wanting. Premaxillary forming mouth border above. Interclavicles present."

Those features of the order which appear to the ordinary observer most striking are the presence of the maxillary barbels above noticed; the presence, in most cases, of additional pairs of barbels about the mouth, near the tip of the upper or the lower jaw, or both; the absence of scales, and the presence, in many species, especially those found in tropical waters, of bony plates. These sometimes form a more or less perfect coat of mail on the sides of the body; at other times, they form a shield on the top and back of the head. Another feature is the development, in most cases, of the first ray in the dorsal and pectoral fins as a strong, stiff, sharp, serrated spine, which forms an effective weapon of defence. The spines of the pectoral fins are strongest, and they are usually 'set,' that is, firmly erected, whenever the fish is caught or attacked. These spines are a source of much annoyance to fishermen, and there are few persons who have ever been boys and fished in the creeks or millponds of the eastern states, that have not had some painful experience with the 'horns' of a cat-fish. Thoreau speaks of the cat-fish as "a blood-thirsty and bullying race of rangers, inhabiting the river bottoms, with ever a lance in rest, and ready to do battle with their nearest neighbor. I have observed them in summer, when every other one had a scar upon his back where the skin was gone, the mark of some fierce encounter."

The articulation of the pectoral spine is somewhat peculiar. When erected, it cannot be depressed directly, without breaking it, but by rotating it toward the animal it can be laid down without difficulty. This is equally easily done, whether the animal be dead or alive.

The wounds made by the spines of the cat-fish are often painful, and sometimes heal with difficulty. This seems to be due, not to any specific poison, but to the jagged character of the cut, and to the slimy skin which is rubbed off from the spine. In one genus, however (*Noturus*), there is certainly a poison gland connected with the pectoral spine.

Another characteristic of most of the Nematognathi is the presence of an adipose dorsal fin, as in the Salmonidæ, Characinidæ, etc. In some cases this adipose fin has distinct rays, and in others it is supported by a stiff spine.

The teeth in all the Nematognathi are small and sub-equal, villiform or granular, or in some cases, entirely wanting. The air-bladder is usually large, and is connected by a slender duct with the œsophagus, as in other 'soft-rayed' fishes. The ventral fins are present, usually eight to ten-rayed, without spine, and abdominal in position. The anal fin is without spine and usually long.

All the Nematognathi are carnivorous fishes. Most of them inhabit fresh waters, but many are found in the sea. The latter, however, never venture to any considerable depths, and most of them sometimes ascend the rivers. None are deep-sea fishes. They are most abundant in tropical waters, a greater variety of species being found in South America than in any other continent, although the rivers of Africa also teem with them. Few of them reach the colder parts of the temperate zones. But one species (*Silurus glanis*) is found in Europe, and none, either marine or fluviatile, inhabit the waters of the United States west of the Rocky Mountains, their range in the eastern Pacific not extending north of the Gulf of California.

In size the Nematognathi vary greatly: from two inches in length to six feet or more. Few of them are much valued as food; most of them, especially the marine species, having rather tough and flavorless flesh.

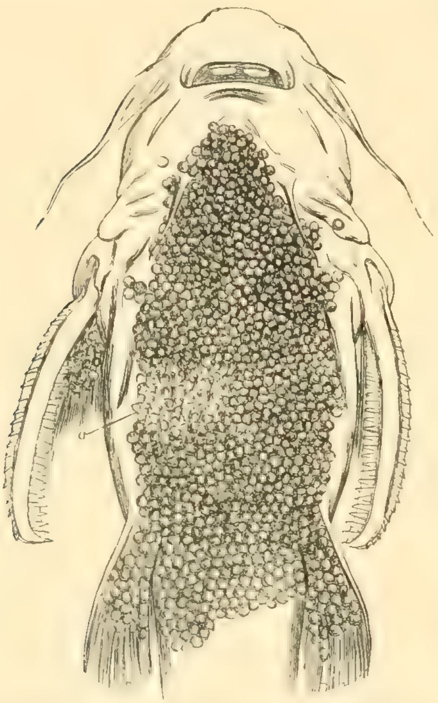


FIG. 76. — Abdomen of *Platystacus batrachus*, with the ova attached; at *a* some have been removed.

As to the origin of the Nematognathi, the following remarks of Professor Cope seem to me reasonable: "This division is the nearest ally to the sturgeons (Chondrostei) among Physostomous fishes, and I imagine that future discoveries will prove that it has been derived from that division by descent. . . . The affinity of the cat-fishes to the sturgeons is seen in the absence of symplectic, the rudimental maxillary bone, and, as observed by Parker, in the interclavicles. There is a superficial resemblance in the dermal bones. The rudimental mesopterygium shown by Gegenbaur to exist in the young Siluridæ, the præcoracoid arch, and the ventral fins, are shared with the sturgeons and other divisions."

One of the families (Hypophthalmidæ) at present referred to this order, differs from all others, according to Cope, in having the lower pharyngeals united for their whole length.

The Nematognathi are all placed by Dr. Günther in a single family, Siluridæ. This is certainly unnatural, as the differences between many of the different members of the group far outweigh the distinctions existing between the currently recognized families of Acanthopteri. Professor Cope divides them into three families, Siluridæ, Aspredinidæ, and Hypophthalmidæ. Professor Gill arranges them in eleven families. The present writer has had no opportunity to form a definite opinion of the value of most of these families, but for the present is disposed to follow Professor Gill's arrangement. The different families now follow in order.

The family of ASPREDINIDÆ is characterized especially, according to Cope, by the absence of the opercle. The adipose fin is wanting, and there is no spine in the dorsal. The eyes and mouth are small. There are six barbels. The gill opening is reduced to a small foramen. The skin is either smooth or covered with bony lumps or tubercles. About ten species are known, all from the fresh waters of the north-

eastern part of South America. The species reach a length of about eighteen inches.

The principal genus is *Platystacus* (*Aspredo*). The species of this group are noted for the method in which the eggs are guarded after exclusion. Contrary to the usual rule among fishes, this office is taken by the female. According to Dr. Günther, "during the time of propagation, the lower side of the flat trunk of the female [*Aspredo*] assumes a soft and spongy texture. After having deposited the eggs, the female attaches them to, and presses them into, the spongy integument, by merely lying over them. She carries them on her belly as the Surinam toad (*Pipa*) carries her ova on her back. When the eggs are hatched, the excrescence on the skin disappears and the abdomen becomes smooth as before."

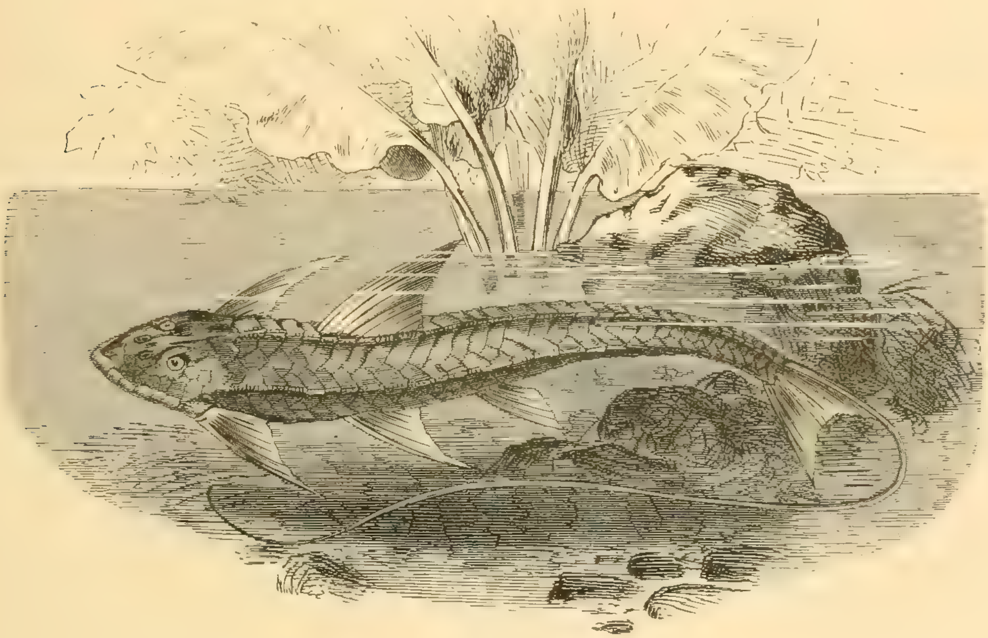


FIG. 77.—*Loricaria cataphracta.*

The SISORIDÆ are small fishes from the mountain streams of farther India and Bengal. They have a single dorsal fin, small eyes, reduced gill openings and naked or mailed skin. In one genus, *Pseudecheneis*, a sucking disc, formed of transverse plaits of skin, exists on the breast, between the pectoral fins, enabling the fish to resist the current by clinging to stones. In another genus, *Exostoma*, the thick lips with reflected edges form a sort of sucking disc which serves a similar purpose.

The LORICARIIDÆ (including CALLICHTHYIDÆ) are small cat-fishes from the fresh waters of South America, east of the Andes. They have the small inferior mouth and narrow gill openings of the preceding family, and, with few exceptions, the body and head are entirely covered by a coat of mail made of interlocking bony plates. The lips are thick, the barbels few and short, the dorsal fin well forward, the adipose fin wanting, or supported by a stiff spine. More than a hundred species are known. Of the genera, *Loricaria* is remarkable for the slenderness of its body: *Chætostomus* and others, for the presence of a bunch of stiff erectile bristles or spines on the

interopercle, which is very movable. *Callichthys* has the bony plates on the side arranged in two series, from head to tail, the two meeting about on the level of the eye. The species are said to make nests for their ova, defending them with much spirit, and, at times, to travel overland like the species of *Doras*.

The ARGIDÆ are very similar to the Loricariidæ, differing mainly in the absence of the coat of mail, and in the presence of maxillary barbels only. There seems to be no doubt of the very close relation of the two families. Dr. Günther observes: "I consider *Arges* as a naked *Loricaria*, or, *vice versa*, *Loricaria* as a mailed *Arges;* and although these forms are sufficiently diversified to admit of further subdivision, it is a most artificial method, by which their natural union is destroyed." The five or six known species of Argidæ reach a length of two or three inches only, and inhabit the ponds and springs of the upper Andes on the Peruvian or Pacific slope, where

FIG. 78.—*Clarias anguillaris*, eel-pout.

they take the place occupied by the Loricariidæ on the Atlantic side. They are locally known as "Preñadillas." One of the species (*Cyclopium cyclopum* = *Stygogenes*) has "received some notoriety through Humboldt's accounts, who adopted the popular belief that they live in subterranean waters within the bowels of active volcanoes of the Andes, and are ejected with streams of mud and water during eruptions. Humboldt himself considers it very strange that they are not cooked and destroyed whilst they are vomited forth from craters or other openings. The explanation of their appearance during volcanic eruptions is that they abound in the numerous lakes and torrents of the Andes, that they are killed by the sulphuretted gases escaping during an eruption, and swept down by the torrents of water issuing from the volcano." (*Günther.*)

In the CLARIIDÆ the body is eel-like, and the dorsal and anal fins are extremely long, the former extending from the nape to the tail. A peculiar accessory gill is attached to the posterior edge of the second and fourth branchial arches, and is

received in a cavity behind the gill-cavity proper. The head is mailed above, the body naked; there are eight barbels, and the mouth is of moderate size. "The skeleton is formed by a soft, cartilaginous substance covered by mucous membrane, in which the vessels are embedded." The species inhabit the mud and swamps of India, East Africa, and the East Indies. They are among the largest of the Nematognathi, some of them reaching a length of six feet. Nearly thirty species are known.

The Plotosidæ (including Chacidæ) are naked cat-fishes, with a short first dorsal above the pectoral, and a very long second dorsal, which is similar in form to the anal, and is connected with the latter around the tail. The gill membranes are united and free, or more or less joined to the isthmus, and barbels are developed around the mouth, which is commonly large. About a dozen species are known, from the fresh or brackish waters of India, Australia, and Polynesia, most of them entering the sea. They reach a length of one or two feet.

The great majority of the Nematognathi belong to the typical family of Siluridæ, which, even in the restricted sense in which it is understood by Dr. Gill, contains upwards of one hundred genera, and over seven hundred species. The members of the family agree in having the skin naked or imperfectly mailed; the operculum present; the dorsal fin short (rarely wanting), inserted above or in front of the ventrals; the adipose fin without spine (rarely wanting); the lower pharyngeals separate; the barbels about the head well developed. Members of the family are found in all parts of the world where any of the order of Nematognathi occur. To this family belong all of the marine species. In the present work we can only glance at the principal sub-families and some of their leading genera.

The typical sub-family, or Silurinæ, has the dorsal fin very short and the anal fin very long, while the adipose fin is rudimentary or wanting. The gill membranes are more or less free from the isthmus. The species of this group belong entirely to the Old World, being especially abundant in the fresh waters of the East Indies, Southern Asia, and Africa. Eighty species are enumerated by Dr. Günther. A single one is found in Europe, being the only Siluroid fish in that region. This is *Silurus glanis*, the Wels of the Germans, the Saluth of the German Swiss, the sheat-fish of the English, the *Silurus* of the Latins, *Σίλουρος* or *Γλάνις* of the Greeks. Next to the sturgeon, the *Silurus* is the largest fish in Europe, reaching at times a weight of three hundred to four hundred pounds. In its distribution it is confined to central and eastern Europe, not being found in Great Britain, France, Spain, or Italy. Valenciennes speaks of it as a lazy fish: "it holds itself in the depths on bottoms of clay or mud; it hides itself there, and is warned of the approach of its prey by means of its barbels; this renders it difficult to take by means of nets, as the latter pass over it. In times of storm it rises to the surface, and thus it happens that it is sometimes strewn on shore by the waves.

"It is very voracious. It is said that of all fishes it spares only the perch, and this because of its spines. It destroys many aquatic birds, and it is said that it does not spare even the human race. On the 3d of July, 1700, one was caught by a peasant at Thorn, which had a small child whole in its stomach." Stories are also told of its having swallowed whole children and young girls in Hungary, and in Turkey even a grown woman, with a ring and a purse full of gold; but I fear, however, that on these cat-fish stories we must draw the line somewhere.

The Bagrinæ have a short dorsal fin placed in front of the ventrals, a long adipose fin, a short anal fin, teeth on the palate, the gill membranes free from the isthmus, and

eight barbels. Nearly all the sixty or seventy known species inhabit the streams of the East Indies, and of neighboring parts of Asia. Two of them, belonging to the typical genus *Porcus* (*Bagrus*), are found in the Nile, and reach a length of five or six feet.

The Ictalurinæ are the cat-fishes of North America. They are the only members of the order which inhabit the fresh waters of our continent, and with the exception

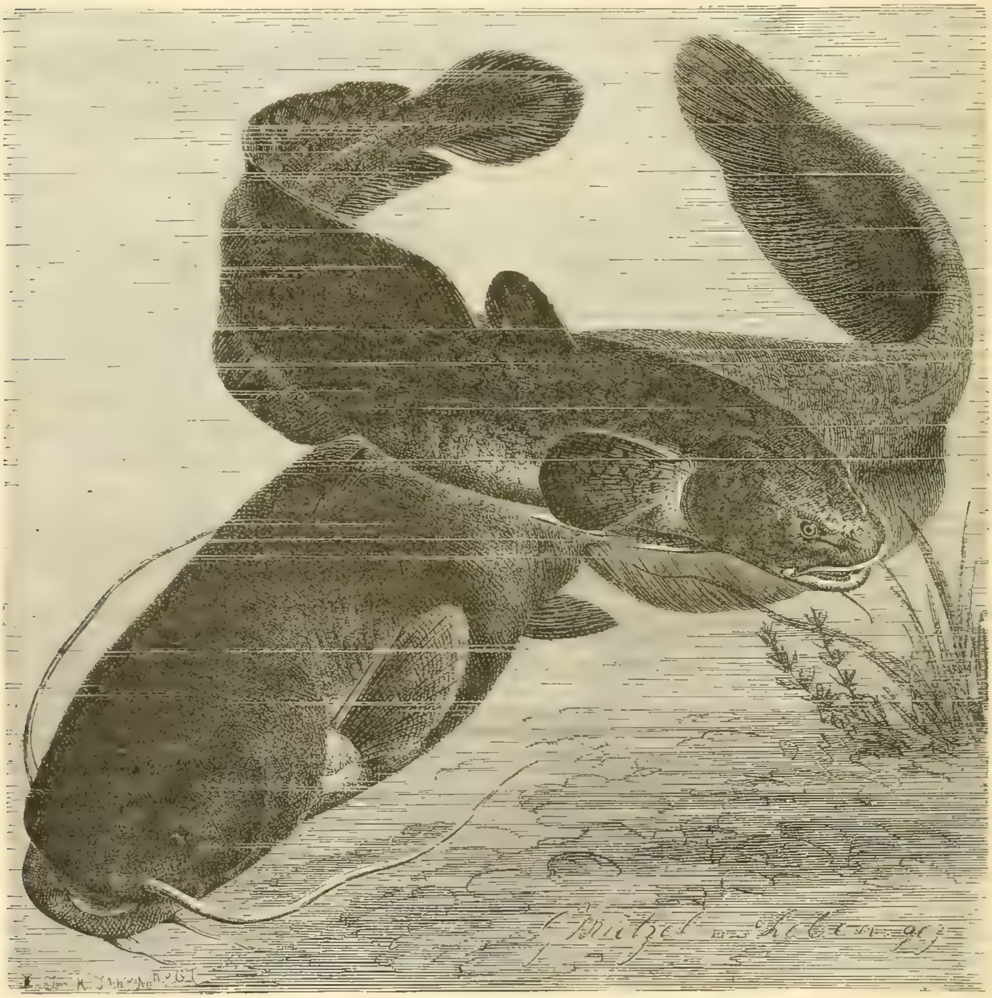


FIG. 79. — *Silurus glanis*, sheat-fish (below); *Lota lota*, burbot (above).

of one or two Asiatic species of *Amiurus* they are strictly confined to that region. One species is known from Mexico, and another from Central America, while two or three extend their range northward into the British possessions. With these exceptions the entire sub-family is confined to that part of the United States which lies east of the Rocky Mountains, and within this region there is scarcely a permanent stream or pond which has not one or more species of cat-fish, 'bull-head' or 'horned-pout.'

The North American cat-fishes agree in having the skin everywhere entirely naked

and smooth, the mouth rather large, with thin lips and eight barbels, the palate toothless, the gill membranes free from the isthmus, the adipose fin short, the dorsal fin short, armed like the pectoral with a sharp spine, and the anal fin of moderate length. Twenty-five species are well known, and these are usually placed in five genera, although two of these (*Gronias* and *Amiurus*) are very similar to *Ictalurus*.

The genus *Noturus* is distinguished by the form of its adipose fin, which is long and low, adnate to the back, and joined to the caudal. Its species, eight or nine in number, are known as stone-cats, and are very small in size, most of them not exceeding six inches in length. They abound in small brooks, among logs and weeds, in the southern and western states. The wounds produced from the sting of their sharp pectoral spines are excessively painful, in character much like those caused by the sting of the dorsal spines of *Scorpæna*, and much more severe than an ordinary bee-sting. In the axil of the pectoral is a pore, which is probably the opening of the duct of a poison gland. "From it," observes Professor Cope, who was the first to notice this character of *Noturus*, "may frequently be drawn a solid gelatinous style ending in a tripod, each limb of which is dichotomously divided into short branches of regular

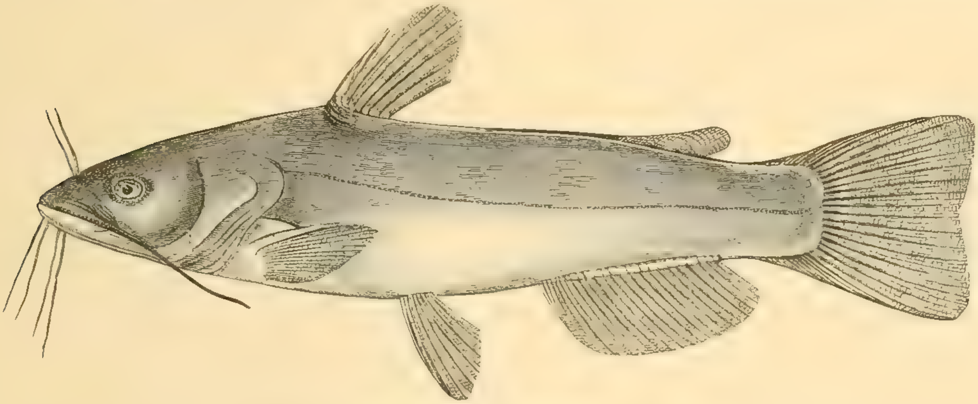


FIG. 80.— *Amiurus nebulosus*, horned-pout, bull-head.

length." Nothing further is known of this poison gland, a feature which is well worth a thorough study.

The genus *Leptops* contains a single species of large size, the mud-cat (*Leptops olivaris*), living in muddy bottoms of sluggish streams and lakes throughout the west and south. It has a large flattened head and projecting lower jaw, and is especially distinguished from the species of *Amiurus* by the arrangement of its teeth.

The genus *Gronias* comprises a single species (*G. nigrilabris*), a small blind cat-fish, a few specimens of which have been taken in a cave in southeastern Pennsylvania. It differs from *Amiurus* only in the partial obsolescence of its eyes, and it is doubtless a recent offshoot from some of the eyed species found in that region.

The genus *Amiurus* comprises most of the common cat-fishes, fifteen species being at present recognized. Of these, the best known and most abundant species is *Amiurus nebulosus*, the common horned-pout or bull-head of New England, the small cat-fish of the great lakes, and generally distributed in the ponds and bayous of the north and east. Lately it has been introduced into the waters of California, where it has thrived remarkably, and already it is one of the most important food-fishes of the Sacramento basin. It is an especial favorite with the Chinese at San Francisco.

Notwithstanding its homely appearance, this cat-fish is much superior as food to many species which have a higher reputation.

The horned-pout is a sluggish fish, fond of the mud, and growing best in weedy ponds and waters which have no current. They stay near the bottom and move slowly about with their barbels widely spread, watching for anything eatable. They will take any kind of bait from an angle-worm to a piece of a tin tomato-can; they bite firmly, and without any sort of coquetry, and rarely fail to swallow the hook. They are very tenacious of life, and will live in any sort of pond or pool where frogs or salamanders can exist. They can endure removal from water longer than any other of our fresh-water fishes, except *Amia calva* and perhaps *Umbra limi.* They spawn in the spring, and the adult fishes lead the young in great schools near the shore, apparently caring for them as a hen cares for her chickens.

Most of the species of *Amiurus* are brown in color, and have the caudal fin truncate. There are other species in which the caudal is more or less forked, and the coloration more silvery or more black. These species reach a much larger size, two of them, *Amiurus nigricans*, the great lake cat-fish, and *Amiurus ponderosus*, the great Mississippi cat, often exceeding the weight of one hundred pounds. The latter, which is the largest of our cat-fishes, perhaps reaching two hundred pounds.

The genus *Ictalurus* comprises the channel-cats, species distinguished from *Amiurus* by the backward prolongation of the supra-occipital bone, which in its emarginate apex receives the pointed anterior end of the second interspinal bone, thus forming a continuous bony bridge under the skin from the skull to the dorsal fin. The skin is thin, the color silvery, and the caudal fin is deeply forked. The channel cats, of which three species are known, live in the running streams, and are much more active than the *Amiuri*, and correspondingly less tenacious of life. They reach a weight of eight to fifteen pounds. The most widely distributed species is *Ictalurus punctatus*, an excellent food fish.

The sub-family Pimelodinæ represent in tropical America the Ictalurinæ of the north. A few species are also found in Africa, the total number now known being nearly one hundred. None of them have more than six barbels; many are noteworthy for the spatulate form of the long snout, and still others for the great length of the adipose fin. Some have teeth on the palate, while others have this region naked. Nearly half the species are referred by Dr. Günther to the typical genus *Pimelodus*, to which genus all the North American cat-fish were very erroneously referred by Valenciennes and by many American writers, both before and after him.

The Ariinæ, or sea cat-fishes, resemble in a general way the channel-cats (*Ictalurus*) of our rivers. The nostrils are, however, closer together and without barbels, the number of these appendages being thus reduced to six or four. There is also a bony shield, 'occipital process,' covering the posterior part of the head and the nuchal region, and behind this a smaller ante-dorsal shield before the dorsal fin. The skin of the head sometimes covers these membrane bones, but in most cases they are exposed, and very hard. The dentition varies very much among the Ariinæ, but there are usually teeth on the palate. The skin of the body is usually smooth.

The Ariinæ are mostly rather large fishes, ranging from less than a foot to more than five feet in length. They are held in low esteem as food. Most of them are marine, living near the shore, especially on sandy bottoms, and often found in the surf. More than a hundred species are known, three fourths of which belong to the typical genus *Galeichthys* (*Arius*). They are most numerous in the East Indies, and

on both coasts of Central America, and southward. Two species, the gaff-topsail cat (*Ælurichthys marinus*) and the sea-cat (*Galeichthys felis*), abound everywhere on the South Atlantic and Gulf coast of the United States, although singularly enough neither of these, nor any other species, has been found on the coast of Cuba. The character of the coral shores of that island is probably unfavorable to them, and the channels which surround Cuba are perhaps too deep for them to cross.

In many — perhaps most — of the species of this group the eggs, which are larger than peas, are taken into the mouth of the male, and are there cared for until hatched.

The Bagariinæ comprise about twenty species of fresh-water Siluroids, mostly of small size, inhabiting the streams of the East Indies and southern Asia. These have the head naked above, and the nostrils close together, with a barbel between them. Some of them, living in swift waters, have on the breast a sucking disc, formed of longitudinal plaits of skin, being thus enabled to resist the force of the streams.

The Doradinæ are characterized by the restriction of the gill openings to the sides by the adhesion of the gill membranes to the isthmus; the nostrils are well separated, and the general arrangement of the fins is not unlike that found in the Ariinæ. The mouth is generally small, the sharp snout projecting beyond it, and in many species the lateral line is armed posteriorly with spinous shields. About sixty species are known, nearly all of them inhabiting the fresh waters of tropical South America east of the Andes, where they form a prominent feature of the fish fauna. A single genus, *Synodontis*, with numerous species, inhabits the streams of Africa.

Concerning the species of *Doras*, Dr. Günther remarks: "These fishes have excited attention by their habit of traveling during the dry season from a piece of water about to dry up in quest of a pond of greater capacity. These journeys are occasionally of such a length that the fish spends whole nights on the way, and the bands of scaly travelers are sometimes so large that the Indians who happen to meet them fill many baskets of the prey thus placed in their hands. The Indians supposed that the fish carry a supply of water with them, but they have no special organs, and can only do so by closing the gill openings, or by retaining a little water between the plates of their bodies, as Hancock supposes. The same naturalist adds that they make regular nests, in which they cover up their eggs with care, and defend them, male and female uniting in this parental duty until the eggs are hatched. The nest is constructed at the begining of the rainy season, of leaves, and is sometimes placed in a hole scooped out of the beach."

The Rhinoglaninæ comprise two or three species of very small cat-fishes, less than three inches in length, from the Nile and the Ganges.

The Malapterurinæ, distinguished by the absence of the dorsal fin, comprise three species, which reach a considerable size, and are found in the rivers of northern Africa. One of them, the electric cat-fish of the Nile, *Malapterurus electricus*, has excited much interest among anatomists. Its electric organ, according to Dr. Günther, "extends over the whole body, but is thickest on the abdomen; it lies between two aponeurotic membranes below the skin, and consists of rhomboidal cells, which contain a rather firm gelatinous substance."

The shock from this animal is said by Adanson to resemble that from a Leiden jar. It is communicated through an iron rod as well as by direct contact. This is true also of the shock of the electric rays. One of the typical specimens of *Narcine umbrosa*, an electric ray, was stabbed, when alive, with a pocket knife by a fisherman

at Key West. The animal gave a vigorous shock, to the surprise of its captor, who was unacquainted with its electric powers.

The Nematogenyinæ comprise about three species of small fishes from South America. These have the dorsal above the ventrals, and approach in many respects the next family, with which they are associated by Dr. Günther.

The family Trichomycteridæ is distinguished from the Siluridæ by the position of the dorsal fin, which is inserted behind the ventrals, the latter fins being sometimes absent. About fifteen species are known; small fishes inhabiting the Andean regions in South America, some of them at great altitudes. Some of them (sub-family Stegophilinæ) are very small fishes which live in the gill cavities of larger Siluroids. They

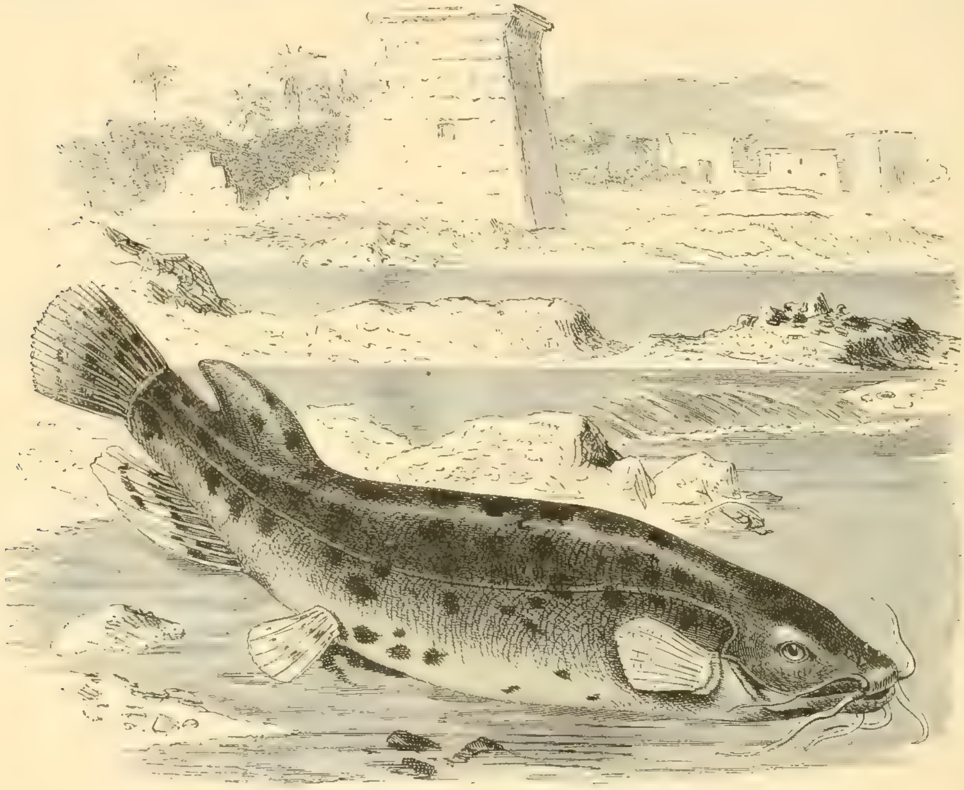


Fig. 81.—*Malapterurus electricus*, electric cat-fish.

are probably not parasites, but enter these cavities for protection merely. The resemblance of the fishes of this family to the Cobitidæ, or loaches, has been noticed by Dr. Günther. Their likeness in appearance and habits, and even in coloration, offers "a striking example of the fact that similar forms of animals are produced under similar external physical conditions."

The family of Hypophthalmidæ diverges from the other Nematognathi, as already stated, in the unmodified character of the anterior vertebræ. The lower pharyngeal bones are firmly united, and the number of branchiostegals much increased. The gill openings are very wide, and the gill arches are armed with long gill rakers. The dorsal fin is behind the ventrals, and the adipose fin is very small. There are six barbels. The skin is everywhere smooth. The physiognomy is peculiar from the

inferior position of the eyes, which are usually below the level of the mouth. The six or eight known species inhabit the rivers of northern Brazil and Surinam.

According to Dr. Günther, "the first appearance of Siluroids is indicated by some fossil remains in tertiary deposits of the highlands of Padang, in Sumatra, where *Pseudotropius* and *Bagarius*, types well represented in the living Indian fauna, have been found. Also, in North America, spines referable to cat-fishes have been found in tertiary formations."

Order VI.—SCYPHOPHORI.

The small order of Scyphophori is placed by its author, Professor Cope, between the Siluridæ and the Cyprinidæ; but, according to Professor Gill, its most intimate relations are with the Gymnonoti. The following are the technical characters originally assigned to it: Physostomous fishes, with the "parietals narrow, distinct from each other and the supra-occipital. Pterotic large, funnel-shaped, enclosing a chamber which expands externally, and is covered by a lid-like bone. No symplectic. Opercular bones present. Anterior vertebræ unaltered. No mesopterygium. Basis cranii simple. No interclavicles."

About fifty-five species of Scyphophori are known, inhabiting the rivers of tropical Africa, where many of them are important as food-fishes. They have an oblong or elongate form, the head naked, the body scaly, the dorsal fin rather long, of soft rays only, the mouth usually small, and the gill openings reduced to a small slit. All of the species possess a rudimentary electric organ on each side of the tail. This is said to be "without electric functions, but evidently representing a transitional condition from muscular substance to an electric organ. It is an oblong capsule, divided into numerous compartments by vertical transverse septa, and containing a gelatinous substance."

Two families are usually recognized in this order; the Mormyridæ, having the ventral, anal, and caudal fins well developed, and the tail diphycercal; the other, Gymnarchidæ, with the lower fins all wanting, and the isocercal tail without a caudal fin. Of the latter family, a single species only, *Gymnarchus niloticus*, is known. This fish reaches a length of six feet, and is remarkable for the cellular structure of its air-bladder, resembling that of *Amia* and *Lepidosteus*, and probably similarly used as an imperfect lung.

Species of *Mormyrus* found in the Nile were "an object of veneration to the ancient Egyptians, and [its representation] therefore frequently occurs in their emblematic inscriptions. They abstained from eating it because it was one of the three different kinds of fishes accused of having devoured a member of the body of Osiris, which, therefore, Isis was unable to recover when she collected the rest of the scattered members of her husband." (*Günther.*)

Order VII.—TELEOCEPHALI.

The great majority of the true fishes are, in Professor Gill's classification, referred to a single order, which is termed by him Teleocephali. This includes the orders of Glanencheli, Haplomi, Isospondyli, Plectospondyli, Percesoces, Synentognathi, Percomorphi, and Pharyngognathi of Professor Cope's system, or the orders of [Gymnonoti] Eventognathi, Isospondyli, Haplomi, Synentognathi, and Acanthopteri of the arrangement adopted by Jordan and Gilbert.

In regard to these different groups, there is no doubt that each represents one or more diverging lines of descent, and on the other hand that they are all more or less intertangled through the presence of intermediate forms. The reasons for placing all these forms in one order, as well as the general characters of that order, are thus indicated by Professor Gill: "Among the most generalized of the typical fishes, and which have been by common consent regarded as most nearly allied to the Ganoids, are the physostomous Teleocephals, best known under the forms of the Cyprinoids, Clupeoids, and Salmonoids. With these the pikes, Scomberescoids, and perches, and, in fact, all those forms most familiar to men at large, numerous as they are, appear to agree in all material respects as to skeletal peculiarities and the character of the brain. . . . It may be said that a *general* description of the skull and shoulder girdle of a cod, a perch, a mullet, a pike, a salmon, or an electric eel, would *almost* equally well apply to the one as to the other, or any other teleostean fish, so far as the *simple number* and essential connection of the bones are concerned. The frontal bones may be single or double, the anterior sphenoid may be present or absent, the palatine and pterygoid bones may be distinct, or, as in the electric eel, in part fused together, the scapular arch may be attached by one or two processes to the skull, a mesocoracoid may or may not be persistent, and even the paraglenal bones may be quasi-cartilaginous; but the agreement in other respects is so close in contrast with the representatives of other orders that the exigencies of classification seem to be best met by the union of all such in one order. In all, the deviations in the skull are comparatively slight, and the scapular arch is composed of a post-temporal and postero-temporal, the latter connecting with the proscapula, while the paraglenal or coracoid is differentiated into at least a hypercoracoid and a hypocoracoid, the latter two bearing the actinosts, which are generally four or (rarely) five in number. With the postero-temporal or proscapula is connected a 'post-clavicle,' from which is generally developed a second distal bone, and sometimes (in Clupeidæ) several. The brain, heart, and vascular system generally, and hyo-branchial apparatus are fundamentally similar, but exhibit (especially the last) minor modifications that indicate narrower differences, and that may be used in the distinction of inferior groups. For all the forms possessing the common characters alluded to may be retained the ordinal name Teleocephali.

"If a typical physostome fish (*e. g.* Clupeid) and a specialized physoclist form (*e. g. Perca*, *Blennius*) are contrasted, the differences certainly appear to be considerable, and are exhibited (1) in the presence or absence of a ductus pneumaticus; (2) the position of ventrals, abdominal or anterior; (3) the presence or absence of a mesocoracoid; (4) the junction of the parietals, or their separation by the intervention of a supra-occipital; (5) the presence of articulated branching rays, or their representation by spines; (6) the low or comparatively high insertion of the pectoral fins; and (7) the course of the lateral line, whether decurved in the direction of the abdomen, or curved in the direction of the back.

"But distinct as the forms appear to be when contrasted, numerous forms intervene in which the characters successively disappear, or are combined in different ways, and the most esteemed differential characters (presence or absence of the ductus pneumaticus) are found in forms on the one hand so closely related (Cyprinodontidæ *vs.* Synentognathi), and on the other hand so much differing from the next or adjoining forms, that the demands of classification appear to be best met by their union in one order."

In this view, groups representing several diverging tendencies or lines of descent

are grouped in one order, because at certain points they approach closely to each other. On the other hand, the specialized extremes of some of these lines, as Hemibranchii, Lophobranchii, Plectognathi, Heterosomata, are regarded as forming distinct orders, although the evidence of their descent from certain groups of Teleocephali seems clear enough. It is in some regards unnatural to separate these extreme forms as orders, while leaving the main branches, with their diverging relations, in one group.

As to the facts in the case, there is, however, no essential disagreement, in the views of American ichthyologists at least; and whether the chief subdivisions of the Teleocephali be regarded as sub-orders (as by Dr. Gill) or as orders (as Professor Cope and the writer have preferred to do) is not a question of high importance. It is rather a matter of taxonomic convenience.

Admitting then, for the present purpose, the order Teleocephali as defined by Dr. Gill, we may proceed to the consideration of its several sub-orders. Of these, the first four to be mentioned (Gymnonoti, Eventognathi, Isospondyli, and Haplomi) are distinguished by the presence of a slender duct, connecting the air-bladder with the alimentary canal, as is also the case with the Nematognathi and Scyphophori already mentioned. These groups so characterized are often known collectively as the Physostomi. With few exceptions their ventral fins are abdominal, and, with the dorsal and anal fins, are devoid of spines.

In the remaining sub-orders, as in the Plectognathi, Pediculati, and other aberrant or specialized orders, there is no pneumatic duct. These groups constitute the Physoclisti, and for the most part the physoclistous fishes have the ventral fins anterior in position, and inarticulate rays or spines in the dorsal, anal, and ventrals. To this there are, however, many exceptions, as will be seen. Of the sub-orders of Teleocephali, the one least specialized in structure, and therefore the 'lowest,' is the Gymnonoti.

SUB-ORDER I. — GYMNONOTI.

This sub-order contains about twenty species of fishes from the fresh waters of South and Central America, chiefly east of the Andes. They are slender and compressed, somewhat eel-like in form, and with tapering tail, which is said to be reproduced when injured in any way. The characters assigned to the order by Professor Cope are the following: "Scapular arch suspended to the cranium, parietal bones extensively in contact, distinct; pterotic normal; a symplectic; opercular bones complete; mouth bounded by premaxillaries chiefly; six or seven basilar pectoral rays; no præcoracoid or interclavicles; anterior vertebræ united, modified, and with ossicula auditus; superior pharyngeal bones subequal, continuous."

More obvious characters, besides the elongate body and the tapering, usually finless, tail, are the absence of the dorsal fin and the great length of the anal fin, the vent being at the throat, and the latter fin extending thence to the end of the tail. The head is naked, the body naked, or more usually covered with small scales. The mouth is small, sometimes placed at the end of a long tube-like snout. The gill openings are narrow, as in the eels, and as in the latter group there are no ventral fins.

The name Glanencheli, given to a portion of this group by Professor Cope, suggests his view that it is intermediate between the eel-like siluroids (Clariidæ) and the eels. A similar view seems to be held by Professor Gill, who observes of the eels that "their affinities with the more generalized forms of the order are possibly with the

Gymnonoti, but the hints furnished by the elongated body and increased number of vertebræ, etc., may be illusive."

The Gymnonoti are usually held to constitute a single family, GYMNOTIDÆ, although by Professor Gill the scaleless electric eel is made the type of a separate family, Electrophoridæ. Professor Cope goes still farther, and, retaining the electric eel alone in the order of Glanencheli, he refers the remaining species, constituting the family of Sternopygidæ, to the group of Plectospondyli (Eventognathi). According to him, the Electrophoridæ are distinguished by the structure of the fins and the

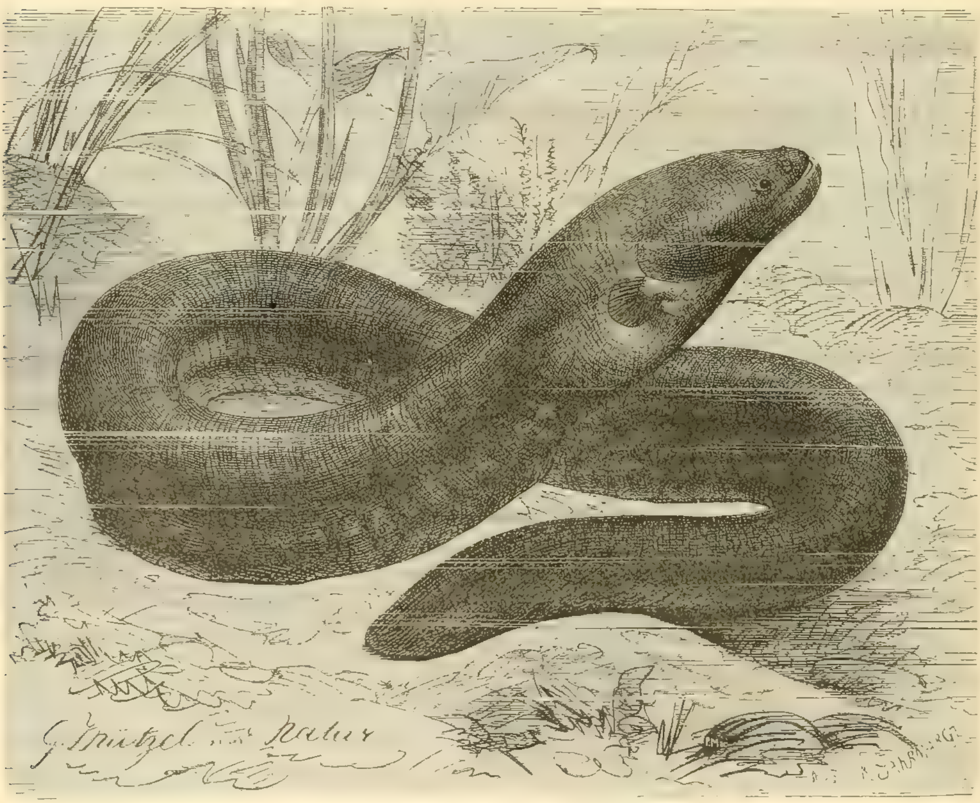


FIG. 82. — *Electrophorus electricus*, electric eel.

rudimental maxillary bones from the Sternopygidæ, with which they have been hitherto associated.

Of the two families, the ELECTROPHORIDÆ is superficially characterized by the absençe of scales, and by the presence of an electric organ on each side of the base of the tail. Its single species, the famous electric eel (*Electrophorus electricus*), inhabiting the rivers of Brazil, has excited much interest among anatomists. It reaches a length of six feet, and is the most powerful of all the various electric fishes. The electric organ "consists of two pairs of longitudinal bodies, situated immediately below the skin, above the muscles; one pair on the back of the tail, the other pair along the anal fin. Each fasciculus is composed of flat partitions, or septa, with transverse divisions between them. The outer edges of the septa appear in nearly parallel lines in the direction of the longitudinal axis of the body, and consist of thin

membranes which are easily torn; they serve the same purpose as the columns in the analogous organ of the torpedo, making the walls or abutments for the perpendicular and transverse dissepiments, which are exceedingly numerous and so closely aggregated as to seem almost in contact. The minute prismatic cells, intercepted between these two sorts of plates, contain a gelatinous matter; the septa are about one-thirtieth of an inch from each other, and one inch in length contains a series of two hundred and forty cells, giving an enormous surface to the electric organs. The whole apparatus is supplied by more than two hundred nerves, which are the continuation of the rami anteriores of the spinal nerves. In their course they give out branches to the muscles of the back, and to the skin of the animal. In the electric eel, as in the torpedo, the nerves supplying the electric organs are much larger than those bestowed on any part for the purposes of sensation or movement." (*Günther.*)

The Sternopygidæ are smaller in size, and the body is covered with small scales, and not provided with an electric organ. The species abound in the rivers of tropical South America; about twenty are recorded.

Sub-Order II. — Eventognathi.

The sub-order of Eventognathi or Plectospondyli comprises a vast assemblage of fresh-water fishes, some of which are found in almost all parts of the globe. They are physostomous fishes, with the anterior vertebræ united and modified as in the Nematognathi and the Gymnonoti, but without most of the other peculiarities of these groups. Professor Cope thus defines the group, which he calls Plectospondyli: "Parietals broad, distinct; pterotic normal, symplectic present; opercular bones all present; no interclavicles; anterior four vertebræ much modified, and with ossicula auditus." The name Plectospondyli alludes of course to the union of the anterior vertebræ. The name Eventognathi, of earlier date, refers to the peculiar development of the lower pharyngeal bones which is found in many of the fishes of this order, — in all which inhabit the north temperate zone. This structure will be described farther on. Those not having falciform pharyngeals (Characinidæ) have been placed among the Isospondyli by Dr. Gill, but they probably belong rather with the present group, although in many regards they resemble the Salmonoid fishes.

The Eventognathi may be divided into six families. Of these, the Characinidæ have the lower pharyngeals not falciform, the jaws usually with teeth, the gill openings various, and an adipose fin usually developed. The others all agree in having the lower pharyngeals more or less falciform and parallel with the gill arches, the mouth toothless, the gill openings restricted to the sides, and no adipose fin. In both groups, so far as I know, there are but three branchiostegals.

The family Kneriidæ is composed of two little minnow-like fishes belonging to the genus *Kneria*, and inhabiting the streams of central Africa. They differ from the Cyprinidæ mainly in the entire absence of pharyngeal teeth.

The Homalopteridæ comprise about thirteen species of small loach-like fishes, inhabiting the mountain streams of the East Indies. They have no air-bladder, and the number of pharyngeal teeth is greater than that seen in the loaches or carp, being from ten to sixteen.

The Cobitidæ, or loaches, are small fishes, all less than a foot in length, inhabiting the fresh waters of Europe and Asia. They are allied to the minnows in structure, but are for the most part slender and somewhat eel-like in form. The mouth is sur-

rounded by rather long barbels. The body is usually covered with small scales, the pharyngeal teeth are few in number, and the air-bladder is enclosed in a bony capsule. Many of the species are provided with an erectile spine below the eye.

The loaches are bottom fishes, feeding on insects and worms, and often burying themselves in the mud or sand. They often lie quiescent for a considerable time, moving very quickly for a little distance when disturbed, in a manner not unlike that of the darters and gobies, which occupy a similar position in American waters.

Some species of loach are found in most European streams, but none occur either in America or Africa. The commonest European species is *Nemachilus barbatula*.

The largest family of fishes is that of Cyprinidæ, the carp family. It comprises

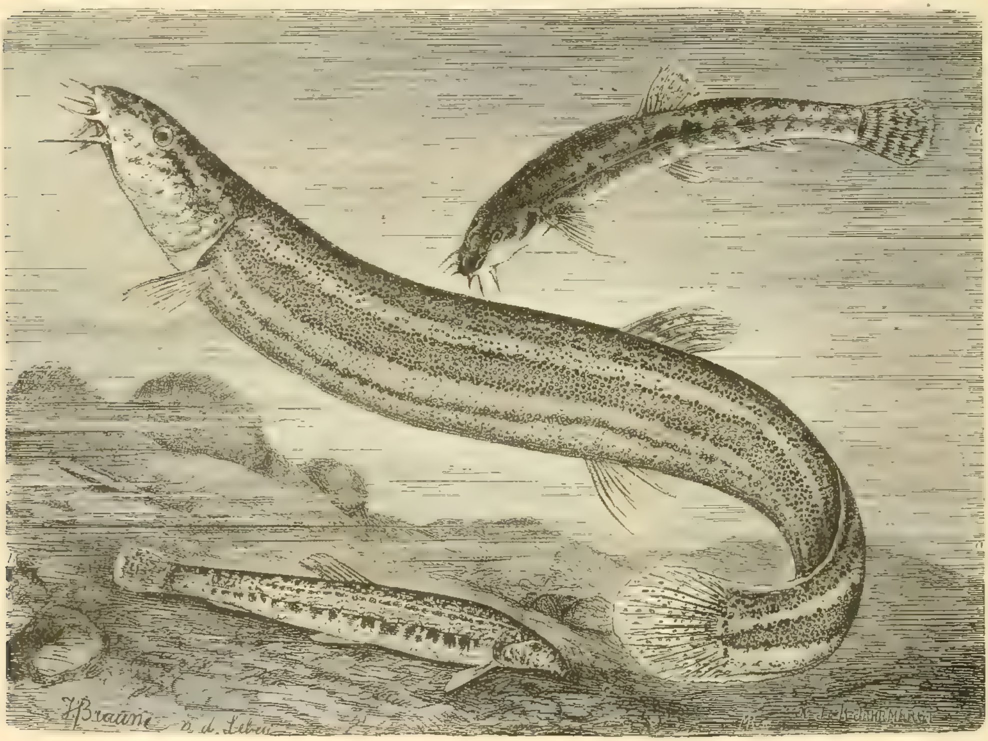


Fig. 83. — *a*, *Misgurnus fossilis*; *b*, *Cobitis tænia*, *c*, *Nemachilus barbatula*, loaches.

upwards of one hundred and seventy-five genera and nearly two thousand species, found in the rivers of all parts of the world except South America, Australia, and the Polar regions. To this family belong the various fishes which have received the vernacular names of carp, chub, dace, roach, minnow, bream, and shiner. Among the Eventognathi, they are distinguished by the following characters: The premaxillaries always form the entire margin of the upper jaw: the mouth is always toothless; the lower pharyngeal bones are falciform, nearly parallel with the gill arches, and each provided with a small number of comparatively large teeth. These teeth are arranged in one, two or three rows, the main row containing from four to seven teeth, the other rows, if present, from one to three. The teeth of the main row are in some cases coarse and blunt, forming molars. In other cases, they are slender and straight, with a narrow groove (grinding surface) on the inner cutting edge towards the point. In

very many species they are hooked at the tip, and the grinding surface is rudimentary or entirely wanting. Besides these, all sorts of varying and intermediate forms are found, and the differences in the numbers and forms of these teeth afford means for the subdivision of the family into genera and sub-genera. In general, those species with long intestines, and consequently herbivorous or rather limnophagous in habit, have straight teeth with developed grinding surface, while the carnivorous species have longer and more hooked teeth. The air-bladder in the Cyprinidæ is without bony capsule. The barbels, when present, are small. The head is naked, the body usually scaly. The ventral fins are abdominal. The dorsal and anal are variable in size and are sometimes armed anteriorly with a spine. The caudal fin is forked.

For the most part, the Cyprinidæ are small and feeble fishes of comparatively simple structure and weak organization. They form a large share of the food of the predatory fishes which inhabit the same waters, and their great abundance, as compared with that of more active species, furnishes another illustration of the (apparent) survival of the unfittest. They spawn profusely and find everywhere an abundance of food. In many cases they check the increase of the predatory fishes by devouring the eggs of the latter.

In many cases the breeding dress of the males is very brilliant, rendering these little creatures, for a time, among the most beautiful of fishes. In spring and early summer, the fins, the sides and other parts of the body are often charged with bright pigment, the prevailing color of which is rosy, although in some cases it is satin-white, orange, yellowish, or jet black. Among American genera, the brightest colored species belong to *Chrosomus*, *Notropis*, and *Rhinichthys*. In very many species, especially in America, the top of the head, the fins, and often the whole body, are covered with small tubercles, outgrowths from the epidermis. These gradually disappear after the breeding season. They are most highly developed in the peculiar genus, *Campostoma*.

In North America about two hundred and sixty species are now known. These are referred to forty genera by Jordan and Gilbert, but many of these genera are simply sections made for the sake of convenience. The division of this group and of other large groups of recent origin into natural genera is subject to many difficulties, because genera with exact definitions and clearly marked boundaries do not exist in nature.

Nearly half the American species belong to the genus *Notropis* (= *Minnilus*). This genus includes most of the smaller and weaker members of the family, ranging from two to eight inches in length, the largest of the entire series being the common shiner, or red-fin, of our streams (*Notropis megalops*). The species of *Notropis* are characterized by the absence of any special peculiarities in mouth, intestines, or fins, and by the presence of but four teeth in the main row on each side. Few, if any of the European or Asiatic species have the teeth so small in number. None of the species of *Notropis* are found in the waters of America west of the Rocky Mountains. In general, the minnows of America have fewer teeth than those of Europe. In but one of our species, *Orthodon microlepidotus*, are there more than five teeth in the main row, and in none are there three rows, or more than two teeth in the lesser row. In the old world, those with more than five teeth in the main row are numerous, as well as those with three rows of teeth or with three teeth in the lesser row. The barbels, in the few American species which possess them are very small, while in their European analogues these appendages are conspicuous. In the eastern United States, there are

no species closely related to any of those found in Europe, but among the species of the great basin of Utah and California are numerous forms closely allied to species found in Europe and northern Asia. Similar resemblances between the fauna of western America and Asia have been noticed in other groups as well as in fishes.

Southward, the Cyprinidæ have extended their range in America as far as central Mexico, but none exist in Central America, South America, or Cuba. While they abound in all parts of Europe and Asia, very few have entered the waters of Africa. Many species have a very wide range of distribution, while numerous others are confined to a single river basin. Such confined species are evidently products of differences in environment.

In Europe, different writers, especially Siebold and Günther, have described many natural 'hybrid' forms among the Cyprinidæ, and certain writers have gone so far as to be able to detect at once the parentage of such hybrids even to the indication of which is the male and which the female parent. I have had no opportunity to study any of these alleged hybrids in life, and so can have no opinion as to the case in Europe. I am sure, however, that the American species behave differently, as in all my somewhat extensive experience as a collector of these fishes, I have never yet found a specimen which I had the slightest reason to regard as a hybrid.

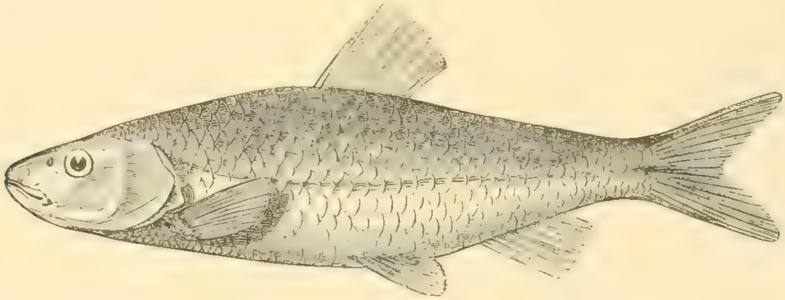


FIG. 84. — *Semotilus bullaris*, fall-fish, silver chub.

Intermediate species and varying species are of course numerous, and many of them are extremely inconstant in their characters. It is, however, quite illogical to ascribe these peculiarities to hybridism. While crosses between fishes which we conceive to be distinct species, may doubtless sometimes occur in nature, I do not believe that, either in America or Europe, they are so frequent as to make any confusion in classifications. In other words, I believe that the great majority of alleged hybrid Salmonidæ and Cyprinidæ in Europe rest either on individual variations, or else on real specific differences, and that Siebold's hypothesis of general hybridization is unwarranted by the facts.

Among the American Cyprinidæ the following are some of the most noteworthy genera: *Campostoma*, the stone-roller, differs from all other known vertebrates in having its very long intestines, which are six or seven times the length of the body, wound in a spiral of some fifteen coils around the air bladder. The species feed on mud, and swarm in all small brooks of the western and southern states in the spring. In this genus, as already noticed, the nuptial tubercles of the male are more developed than in any other, often covering the entire head, body, and fins.

Another remarkable American genus is *Exoglossum*, the single species of which is found in the rivers of the middle states. In this genus the two rami of the lower

jaw are closely united for their whole length from base to symphysis. The contracted lower jaw thus resembles a projecting tongue.

The genus *Notropis*, already mentioned, comprises a host of small species, which abound in all streams east of the Rocky Mountains, thus forming one of the most characteristic features of the fauna of the eastern half of the United States.

The largest species of Cyprinidæ (fall-fishes or chubs) found in the Eastern States belong to the genus *Semotilus*. One of these (*S. bullaris*) reaches a length of eighteen inches, being the largest Cyprinoid found east of the Rocky Mountains. This genus is an ally of the European gudgeon (*Gobio*). Closely related to the fall-fishes is the common horny-head, or river-chub (*Hybopsis biguttatus*), one of the most widely distributed of our fresh-water fishes. West of the Rocky Mountains species of larger size occur. Many of these belong to the European genus *Squalius*, and are closely related to Old World forms. The largest American Cyprinoids belong to the genus *Ptychochilus*. Some of these, in the basins of the Columbia, Sacramento, and Colorado, reach a length of four or five feet, or even more. They are long and slender species, with large mouths, and bear some slight resemblance to the pike.

The genus *Notemigonus*, of which one species, the golden shiner (*N. chrysoleucus*), abounds in the eastern and northern states, represents in America the true bream (*Abramis*). As in other cases, in this family the American species are smaller and feebler fishes than those of Europe.

In the great basin of Utah two genera of small fishes (*Meda* and *Lepidomeda*) are found, which have the short dorsal fin armed with a stout spine, which is formed of two, the posterior fitting into a longitudinal groove in the anterior. All the American Cyprinidæ have the dorsal fin short, usually of eight rays. In many of the Old World genera, especially those of Asia, the dorsal fin is elongate, having fifteen to twenty or more rays, and sometimes preceded by a serrated spine, resembling the spine of the cat-fish.

Of the species with long dorsal the one most celebrated is the carp (*Cyprinus carpio*). This fish is a native of the rivers of China, where it has been domesticated for centuries. Nearly three hundred years ago it was brought to northern Europe, where it has multiplied in domestication, and become naturalized in many streams and ponds. Of late years the cultivation of the carp has attracted much attention in America. It has been generally satisfactory where the nature of the fish has been understood, and where expectations have not been too high.

The carp is a dull and sluggish fish, preferring shaded, tranquil, and weedy waters with muddy bottoms. Its food consists of water insects and other small animals, and vegetable matter, such as the leaves of aquatic plants. They can be fed on much the same things as pigs and chickens, and they bear much the same relation to trout and bass that pigs and chickens do to wild game and game birds. The carp is a very hardy fish, grows rapidly, and has immense fecundity, 700,000 eggs having been found in the ovaries of a single individual. It reaches sometimes a weight of thirty to forty pounds. As a food fish the carp ranks high. Though inferior to the trout, white-fish, shad, and other superior fishes, it compares favorably, when properly cooked, with most of our fishes, either marine or fresh water.

The carp, either native or in domestication, has many enemies. In America, cat-fish, sun-fish, and pike, prey upon its eggs or its young, as well as water-snakes, turtles, king-fishers, cray-fishes, and many other creatures which live about our ponds, and in

sluggish streams. In domestication numerous varieties of the carp have been formed, the "leather-carp" (Lederkarpfen) being scaleless, others, "mirror-carp" (Spiegelkarpfen), having rows of large scales only along the lateral line, or the bases of the fins.

Closely allied to the carp is the gold-fish (*Carassius auratus*). This is also a common Chinese fish, introduced in domestication into Europe and America. The golden yellow color is found only in domesticated specimens, and is retained by

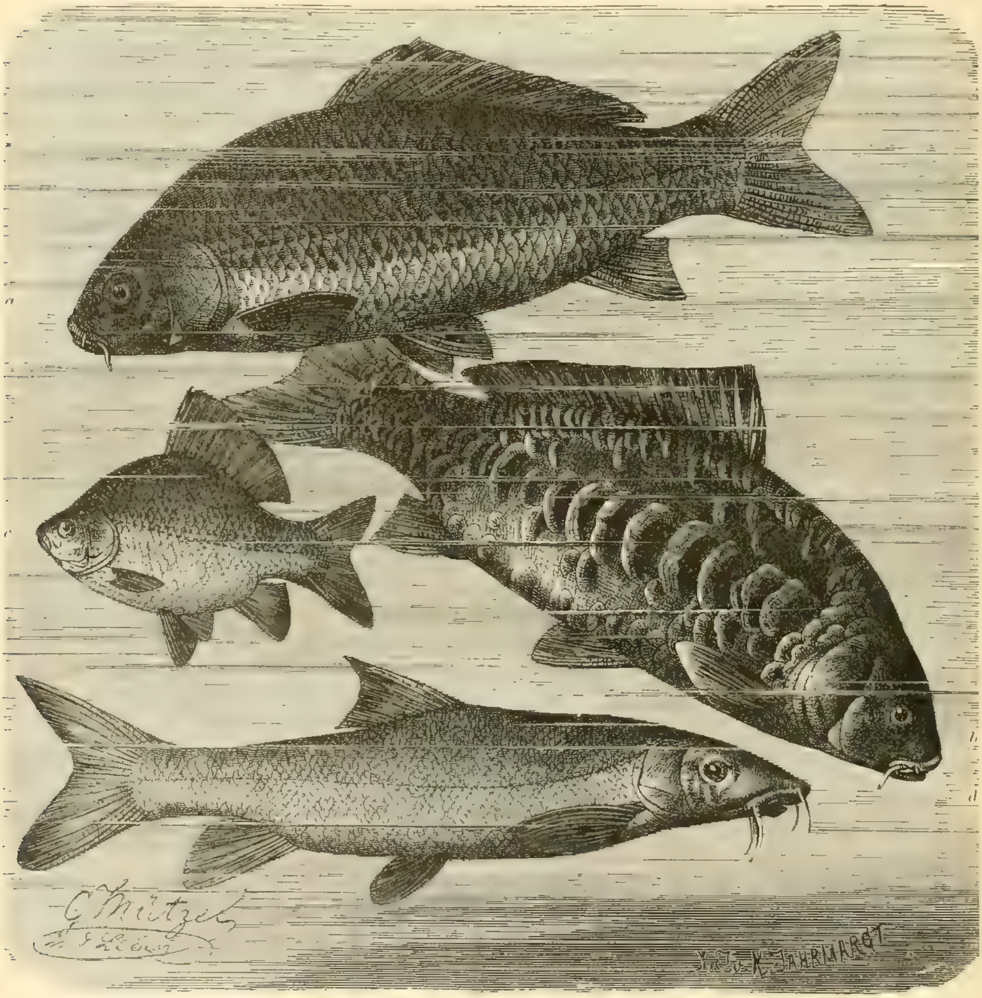


FIG. 85.—*a*, *Cyprinus carpio*, carp; *b*, mirror-carp; *c*, *Carassius auratus*, goldfish; *d*, *Barbus barbus*, barbel.

artificial selection. The native goldfish is olivaceous in color, and where the species has become naturalized (as in the Potomac River, where it has escaped from fountains in Washington) it reverts to its natural greenish hue. The gold-fish is valued solely for its bright colors as an ornamental fish. It has no beauty of form, nor any interesting habits, and many of our native fishes (Percidæ, Cyprinidæ) far excel it in attractiveness as aquarium fishes. Unfortunately they are less hardy. Many varieties and monstrosities of the gold-fish have been produced by domestication.

Allied to the carp is the barbel (*Barbus barbus*), which abounds in the rivers of

Europe. Similar species are found throughout southern India, and one of the barbels (*Barbus mosal*), from the mountains of India, is said to be the largest of the Cyprinidæ, reaching a length of more than six feet, and having scales "as large as the palm of the hand."

More closely allied to American Cyprinidæ are the roach (*Leuciscus rutilus*), the chub (*Squalius cephalus*), the dace (*Squalius leuciscus*), the id (*Idus*), the red-eye (*Scardinius*), the minnow (*Phoxinus*), the gudgeon (*Gobio*), the bream (*Abramis*), the bleak (*Alburnus*), and the tench (*Tinca*). These species receive much more attention from anglers in Europe than their corresponding species do in America. In the United States the Cyprinidæ are one and all considered as "boy's fish," unworthy the notice of the angler, who finds in the trout and bass of our streams a much higher game. The Asiatic species are even more numerous and varied than those of North America and Europe. Their characters need not, however, be further noticed here. As food fishes, the Cyprinidæ all take a low rank. Their flesh is full

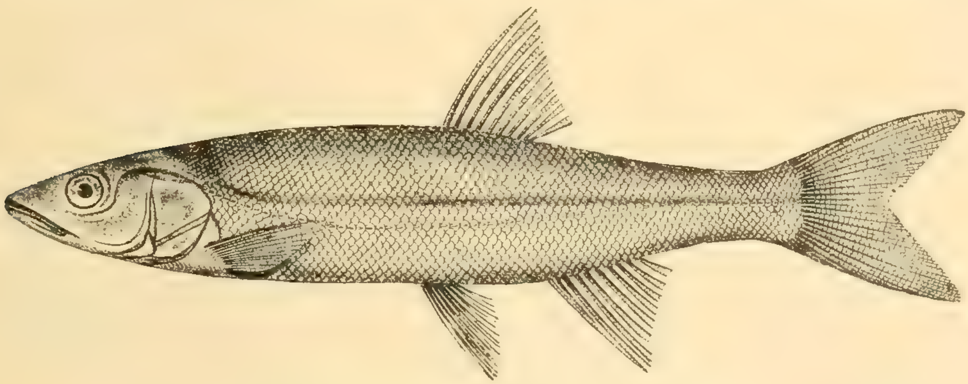


Fig. 86.—*Ptychocheilus oregonensis*, Sacramento 'pike.'

of small bones. It is soft, and readily spoils. When cooked, it is pale, and has little flavor. Thoreau's remark that "a chub is a soft fish; it tastes like brown paper salted," applies to all of them.

Numerous species of fossil Cyprinidæ have been described from the Great Basin and neighboring regions. These belong chiefly or entirely to types now living in the same region. Most of these are known from the pharyngeal bones only.

The suckers, or Catostomidæ, are an off-shoot from the Cyprinidæ, differing chiefly in the structure of the mouth and of the lower pharyngeal bones. The border of the mouth above is formed mesially by the small premaxillaries, and laterally by the maxillaries. The teeth on the lower pharyngeals are small and very numerous, arranged in one series like the teeth of a comb. The lips are usually thick and fleshy, and the dorsal fin is more or less elongate (its rays eleven to fifty in number), characters which distinguish the suckers from the American Cyprinidæ generally, but not from those of the Old World.

About sixty species of suckers are known, all of them found in the rivers of North America except two, which occur in Siberia and China. Only two or three of the species extend their range south of the Tropic of Cancer into Mexico or Central America, and none occur in Cuba or any of the neighboring islands. The majority

of the genera are restricted to the region east of the Rocky Mountains, although species of *Catostomus*, *Chasmistes*, and *Pantosteus* are equally abundant in individuals in the Great Basin and the Pacific slope.

In size the suckers range from six inches in length to about three feet. As food-fishes they are held in low esteem, the flesh of all being flavorless and excessively full of small bones. Most of them are sluggish fishes; they inhabit all sorts of streams, lakes, and ponds, but even when in mountain brooks, they gather in the eddies and places of greatest depth and least current. They feed on insects and small aquatic animals, and also on mud, taking in their food by suction. They are not very tenacious of life. Most of the species swarm in the spring in shallow waters. In the spawning season they migrate up smaller streams than those otherwise inhabited by them. The large species move from the large rivers into smaller ones; the small brook species go into smaller brooks. In some cases the males in spring develop black or red pigment on the body or fins, and in many cases tubercles similar to those found in the Cyprinidæ appear on the head, body, and anal and caudal fins.

The buffalo-fishes and carp-suckers, constituting the genus *Ictiobus* (including *Carpiodes* and *Sclerognathus*), are the largest of the Catostomidæ, and bear a considerable resemblance to the carp. They have the dorsal fin many-rayed, and the scales large and coarse. They abound in the large rivers and lakes between the Rocky Mountains and the Alleghanies, one species being found in Central America, and a species of a closely related genus (*Myxocyprinus asiaticus*) in eastern Asia. They rarely ascend the smaller rivers except for the purpose of spawning. Although so abundant in the Mississippi Valley as to be important commercially, they are very inferior as food-fishes, being coarse and bony. The genus *Cycleptus* contains the black-horse or Missouri sucker, a peculiar species with small head, elongate body, and jet black coloration, which comes up the smaller rivers tributary to the Mississippi and Ohio in large numbers in the spring. Most of the other suckers belong to the genera *Catostomus* and *Moxostoma*, the latter being known, from the red color of the fins, as red horse, the former as sucker. Some of the species are very widely distributed, two of them (*Catostomus teres*, *Erimyzon sucetta*) being found in almost every stream east of the Rocky Mountains. The most peculiar of the suckers in appearance is the hare-lip sucker (*Quassilabia lacera*) of the western rivers.

The large family of CHARACINIDÆ seems to be naturally associated with the Cyprinidæ, although in many respects resembling the Salmonidæ. It inhabits the fresh waters of those regions which have neither Cyprinoids nor Salmonoids, thus in a way representing both in the streams of South America and Africa. About three hundred species are known.

The Characinidæ have the anterior vertebræ coalesced and modified, and the air-bladder communicating by auditory ossicles with the organ of hearing, as in the Cyprinidæ and other Plectospondylous families. They differ from the latter in several respects as regards the skeleton. More obvious distinctions are in the form of the lower pharyngeal bones, which is more like that seen in ordinary fishes, and without the peculiar and specialized teeth seen in the Cyprinidæ, Catostomidæ, and Cobitidæ. The mouth is in most cases provided with teeth, which are of various forms, sometimes broad incisors, sometimes sharp canines, sometimes small or even entirely wanting. An adipose fin is usually but not always present. The pseudobranchiæ are wanting, and there is much variety in the attachment of the gill membranes. The

head is naked, the body scaly. The structure of the fins is in general similar to that seen in the Cyprinidæ.

No Characinidæ are found in the Old World except in Africa. In America a very few extend their range northward into Mexico and the southernmost of the West Indies, and a single one (*Tetragonopterus argentatus*) is abundant in southern Texas. The family is divided by Dr. Günther into eleven sub-families, only the more important of which need be mentioned here.

The Erythrininæ differ from the other Characins in having no adipose fin. The species are all South American, and some of them are large fishes with very strong

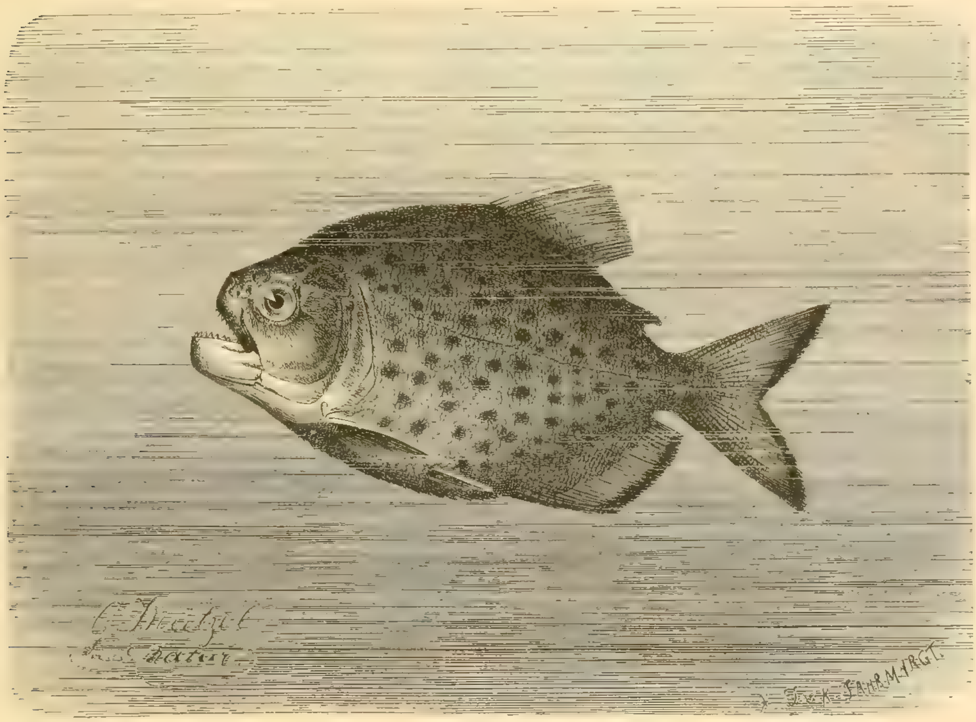


FIG. 87.— *Serrasalmo piranya*, caribe.

teeth. The Curimatinæ, likewise numerous in South America, have the teeth very few or wanting, and the dorsal fin short.

The Citharininæ, with the teeth likewise very feeble, have the dorsal fin rather long. The few species are African. The Anostominæ have the teeth well developed, and the gill membranes grown to the isthmus. They are mostly small fishes from Brazil and Guiana. Allied to them are the very small Nannocharacinæ from Africa.

The largest of the sub-families is that of Tetragonopterinæ, distinguished by the free gill membranes and the incisor-like teeth, which are notched or serrate on the edge. The species are found both in South America and Africa. The largest genus is *Tetragonopterus*, all the species of which are American.

The Hydrocyoninæ differ especially in having the teeth in the jaws conical and very strong. They are voracious fishes, many of them of large size, found in the rivers of Africa and South America. Some of them (*Hydrocyon*, *Cynodon*) reach

a length of four feet, and are very destructive to other fishes. The Distichodontinæ and Ichthyoborinæ are found in northern Africa, species of *Distichodus* being important as food-fishes in the Nile region.

The Serrasalmoninæ have the belly serrated, the dorsal rather long, and the gill membranes free from the isthmus. The numerous species abound in the waters of South America, and some of them are very singular in form. They are nearly all small in size, but according to Dr. Günther, "their voracity, fearlessness, and number render them a perfect pest in many rivers of tropical America. In all, the teeth are strong, short, sharp, sometimes lobed incisors, arranged in one or more series; by means of them they cut off a mouthful of flesh as with a pair of scissors; and any animal falling into the water where these fishes abound is immediately attacked and cut to pieces in an incredibly short time. They assail persons entering the water, inflicting dangerous wounds before the victims are able to make their escape. In some localities it is scarcely possible to catch fishes with the hook and line, as the fish hooked is immediately attacked by the 'caribe' (as these fishes are called), and torn to pieces before it can be withdrawn from the water. The caribes themselves are rarely hooked, as they snap the hook or cut the line. The smell of blood is said to attract at once thousands of these fishes to a spot."

Sub-Order III. — ISOSPONDYLI.

The great sub-order of Isospondyli comprises those physostomous Teleocephali which have the anterior vertebræ separate and unmodified, and a præcoracoid arch developed. The lower pharyngeals have not the form seen in the Cyprinidæ, and there are no auditory ossicles. Many species are provided with the adipose dorsal fin. Within the order there are many modifications of structure. Some of the species are fresh-water fishes; many others are anadromous, that is marine fishes, ascending rivers to deposit their spawn. Others are permanently marine, and still others are adapted for life in great depths. A very large portion of the Bassalian or deep-sea fish fauna is made up of Isospondyli. Such usually have a very feeble osseous and muscular development, and a very strong dentition. They are also often provided with series of phosphorescent spots. Isospondyli are found in all parts of the world except in the rivers of some portions of South America and Africa.

About thirty families of Isospondyli are usually recognized. Most of these group themselves naturally about the important families of Clupeidæ, Salmonidæ, and Stomiatidæ; most of the deep-sea forms being more or less allied to the latter group.

The family of Chirocentridæ contains but a single species, *Chirocentrus dorab*, a large fish of the Indian Ocean.

The Engraulididæ, or anchovies, are small fishes allied to the herrings, but having the mouth very broad, its gape extending nearly to the gill opening, and overlapped in front by a short snout. About seventy species are known, abounding on the coasts of most temperate and torrid regions, and sometimes ascending the streams. They swim in large schools, and are fishes of weak organization. All are silvery in color, and most of them have a burnished silvery lateral band. They are much used as bait, and some of the species are salted or pickled in large numbers. Most of the species belong to the genus *Stolephorus* (*Engraulis*), and the longest known species is the anchovy of the Mediterranean, *S. encrasicholus*.

The Dorosomatidæ, or gizzard shads, are shad-like fishes, having the mouth small, inferior, and toothless, overlapped by a blunt snout. The maxillary is very narrow

and small, in fewer pieces than in the Clupeidæ, which the species otherwise much resemble. They are broad, silvery fishes, rather attractive in appearance, but lean and bony, and therefore considered of little value as food. They inhabit the fresh and brackish waters of the Atlantic coasts of North and Central America, as also those of eastern Asia and Australia. On the Pacific coasts of America and the Atlantic coasts of the Old World they are unknown. They are sluggish fishes, feeding on mud, and remarkable for the muscular character of the stomach, which resembles the gizzard of a fowl. The twelve known species chiefly belong to the genus *Dorosoma* (*Chatoëssus*). The common gizzard or hickory-shad of the United States is *Dorosoma cepedianum*.

The great herring family, or CLUPEIDÆ, comprises fishes with the body oblong or elongate, compressed, covered with cycloid scales, the head naked, the mouth large, with subequal jaws, and the teeth feeble or often wanting. The maxillary is well developed, and composed of about three pieces. There is no lateral line. The gill rakers are usually very long and slender, and the pseudobranchiæ are present. The fin rays are all soft and articulated, and the fins have the positions most usual in soft-rayed fishes. There is no adipose fin. Most of the species have the belly compressed to an edge, and serrated. About one hundred and thirty species are known, some of

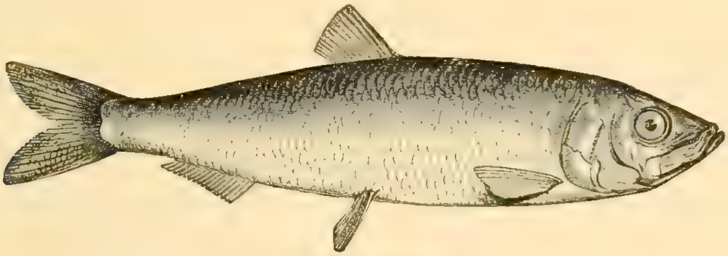


FIG. 88.—*Clupea harengus*, herring.

them found in all seas, and many of them ascending rivers for purposes of spawning. They are mostly fishes of weak organization, swimming in great schools, and forming a large part of the food of predatory fishes. Their importance to man is very great, not from the especial value of individuals, but from their immense number, and the ease with which they may be captured. It is thought that the Clupeidæ comprise a greater number of individuals than any other family in Ichthyology. The principal genus is *Clupea*.

The common herring (*Clupea harengus*) inhabits both shores of the North Atlantic, being found in immense schools. From its great abundance it is one of the most valuable food fishes throughout northern Europe and the corresponding parts of North America. Preserved by smoking, it is found in nearly every grocery store in the United States, and it is also largely salted for food purposes. Very similar to this species is the herring of the Pacific (*Clupea mirabilis*), which inhabits the corresponding latitudes in the Pacific, and is equally abundant, although less important commercially, because less sought for by fishermen.

The alewife, or branch herring (*Clupea vernalis*), a fish not unlike the common herring, abounds on the coast of our northern states and Canada, ascending the rivers with the shad in the spring for the purpose of spawning. It has become land-locked in many of the inland lakes, where it is now permanently a fresh-water fish. This is also true of the Ohio herring, or skipjack (*Clupea chrysochloris*), native in the Gulf of

Mexico, but now abundant as a fresh-water fish throughout the Mississippi valley. This species is rarely eaten, and is of no economic value. Closely allied to the alewife is the glut herring, or blue-back (*Clupea æstivalis*), which on our eastern coast runs later than the alewife, and is smaller and less abundant. The sprat (*Clupea sprattus*) is another species of this type, inhabiting the coasts of Europe.

Still others are the allice shad (*Clupea alosa*), the thwaite shad (*Clupea finta*), inhabiting the coasts of Europe, and the much more valuable American shad (*Clupea sapidissima*), found along the Atlantic coast of the United States. The American shad is one of the largest of the family, and certainly as a food fish is far superior to any of the other large species. It is found along our coast from New England to the Gulf of Mexico, and ascends the different rivers in the spring to spawn. It has been successfully introduced on the Pacific coast, and is now not uncommon in the Columbia River and about the Bay of Monterey.

Species of rich flesh and little ossified skeleton are the different fishes properly called sardines. These are peculiarly excellent when broiled, and may be eaten bones and all with impunity, while in the shad and other herrings generally the numerous small bones are a source of annoyance. The best known of the sardines is the European sardine, or pilchard (*Clupea pilchardus*), the species so extensively preserved in oil in southern Europe. A similar species, but less abundant, is the West Indian "Sardinade España" (*Clupea pseudohispanica*). A larger species, also very close to the European one, and perhaps sometimes to be economically as important, is the California sardine (*Clupea sagax*), which ranges from Oregon to Chili, and this or some similar species is also found in New Zealand and in Japan.

Clupea toli, the 'trabu' of Sumatra, is also extensively fished for the sake of its roes, which are sent to China. Numerous other species of greater or less importance abound in all seas, those of the tropical waters of America being generally smaller in size, and less in value than those of the North.

The genus *Opisthonema*, distinguished by the filamentous prolongation of the last dorsal ray, has two abundant but commercially unimportant species, both American.

The genus *Brevoortia* is distinguished by its pectinated scales and its elongate intestines. The mouth is toothless, and the head is very large. The most important species is the menhaden or mossbunker (*Brevoortia tyrannus*) of the Atlantic coast of the United States. It is a bony and rather coarse fish, but from its great abundance on our coasts its actual economic value in the United States is scarcely inferior to that of any other species, even the cod, or the quinnat salmon. The young are now canned in olive oil as "American sardines." The old fishes are used largely as bait for the cod and other carnivorous fishes. Large factories exist in New England for the purpose of extracting oil from the menhaden; the annual yield of menhaden oil in the United States (according to Goode) exceeding that of whale oil. The refuse from the oil factories is used in the manufacture of artificial fertilizers. In some regions the menhaden are used directly by farmers as manure in fields of Indian corn. One of the most complete and valuable fish biographies yet published is the Natural and Economical History of the American Menhaden, by G. Brown Goode.

All the above-mentioned species have the edge of the belly serrated. There is a small sub-family, Dussumieriinæ, in which the belly is rounded. To this belong a number of small fishes, mostly of tropical America and Asia, two of which occur in the waters of the United States. These are too small to attract popular attention.

Fossil clupeoid fishes are abundant in tertiary and other comparatively recent formations, but many of them appear to belong to families related to the Clupeidæ, rather than to that group itself, as at present defined.

In the family of CHANIDÆ the mouth is small and toothless, the abdomen flattened below, the intestines elongate, and the gill membranes fully united below the isthmus. Two species are known, both found in the Pacific. One of these (*Chanos chanos*) has a remarkably wide distribution, it being abundant in the Gulf of California and in the Red Sea, as well as in various intermediate localities. It reaches a length of about four feet.

The ELOPIDÆ are especially distinguished by the presence of a flat plate or membrane bone between the branches of the lower jaw, somewhat like the plate found in the ganoid genus *Amia*. In other respects, they are much like the herrings, although they reach a much larger size than the latter and have a complete lateral line. The species, four or five in number, are widely distributed in the tropical and semi-tropical seas, although sometimes entering fresh waters. They are little valued as food.

The grande écaille, tarpum or sabalo (*Megalops atlanticus*) of our southern coasts and the West Indies, reaches a length of five or six feet. It is remarkable for the great size of its scales, which are now largely used in ornamental work. It often leaps out of the water, after the manner of the mullets, and instances are recorded of persons having been severely injured by being struck by one of them. A similar species (*Megalops cyprinoides*) is found in the East Indies.

The 'ten-pounder' (*Elops saurus*) is one of the most widely distributed of fishes. It is found on our South Atlantic and Gulf coasts, throughout the West Indies and on both coasts of tropical America, and in the western Pacific from the Cape of Good Hope to China. Where found, it is used chiefly for bait.

The family of ALBULIDÆ consists of a single species (*Albula vulpes*) the bone-fish or lady-fish of our Atlantic coasts, the French mullet or macabé of the Spanish Creoles. Its range is almost co-extensive with that of *Elops saurus*, and it is generally even more abundant. It is a subcylindrical, graceful and beautifully silvery fish, with a small mouth, overlapped by a conical pig-like snout. Its teeth are rounded and granular. It is a gamey fish, taking the hook readily, and in some localities (as Key West) it is held in high esteem as a food fish, while in most others it is used only for bait. The value of food fishes depends as often on local whims and fashions as on real differences in the character of the flesh. The family BATHYTHRISSIDÆ, deep-sea fishes from the North Pacific, is somewhat allied to the Albulidæ and Clupeidæ, but has a longer dorsal fin.

The HYODONTIDÆ, or moon-eyes, inhabit the rivers of the central portion of the United States and British America. They are shad-like fishes, covered with large and very brilliantly silvery scales, and the dentition is very strong, nearly every part of the mouth being armed with strong, curved teeth. These teeth are largest on the tongue. In this family, there is no oviduct, the eggs falling into the abdominal cavity before exclusion. Three species are known, very similar to each other in appearance, and all reaching the length of about a foot. They are very handsome fishes, active and gamey, but of little value as food, the flesh being poor and bony.

The family of GONORHYNCHIDÆ comprises only the sand eel, (*Gonorhynchus gonorhynchus*), an elongate fish with spiny scales, and with barbels about the mouth, found in the western Pacific.

The ALEPOCEPHALIDÆ are fishes intermediate between the clupeoid and salmonoid forms, agreeing with the former in the absence of the adipose fin. They inhabit the deep seas, being among the most widely distributed and characteristic of the Bassalian types. They are black in color and of soft substance. About ten species are now known.

The ALEPIDOSAURIDÆ are deep-sea fishes of large size, remarkable for the great size of their teeth. The body is elongate, and without scales; the mouth is extremely large, with rows of compressed teeth of unequal size, some of those on the lower jaw and the palatines being fang-like. The dorsal fin is very long, covering almost the whole of the back, and there is no adipose fin.

These fishes are found in the deep waters of the Atlantic and Pacific, and in their depths are probably not rare. Occasionally specimens are cast on shore by storms, especially along the Pacific coast of North America, and about Cuba and the Madeira Islands. It is not likely that they ever rise near the surface of their own accord, and when they are forced to do so they are killed by the reduction of the pressure.

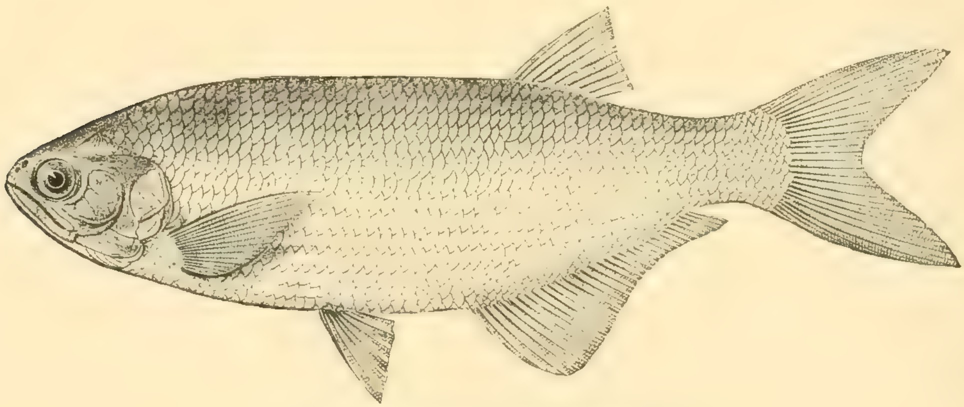


FIG. 89.—*Hyodon alosoides*, moon-eye, toothed herring.

Every part of the body is so fragile that perfect specimens are very rare. The dorsal fin is readily torn, the bones are very feebly ossified, and the ligaments connecting the vertebræ are very loose and extensible, so that the body can be considerably stretched. "This loose connection of the parts of the body is found in numerous deep-sea fishes, and is merely the consequence of their withdrawal from the pressure of the water to which they are exposed in the depths inhabited by them. When within the limits of their natural haunts, the osseous, muscular, and fibrous parts of the body will have that solidity which is required for the rapid and powerful movements of a predatory fish. That the fishes of this genus (*Alepidosaurus*) belong to the most ferocious of the class, is proved by their dentition and the contents of their stomach." (*Günther.*) Dr. Günther elsewhere observes that "from the stomach of one example have been taken several octopods, crustaceans, ascidians, a young Brama, twelve young boar-fishes (*Capros*), a horse-mackerel, and one young of its own species."

Four or five species are known, all belonging to the genus *Plagiodus* (*Alepidosaurus*). The Atlantic species or lancet-fish, (*P. ferox*) has been frequently taken in the Gulf Stream. Another species, *P. borealis*, locally known as the hand-saw fish, is occasionally found on our Pacific coast, and still another, *P. æsculapius*, in Alaska.

The Paralepididæ are small deep-sea fishes allied to the Alepidosauridæ. They are barracuda-like in form and dentition, the body being slender, the teeth strong and some of them fang-like. The dorsal fin is short and far back, and there is an adipose fin behind it. The known species are about five in number, from the waters of Europe and America. One of these (*Sudis ringens*) is known only from a single specimen found by the present writer in the body of a hake (*Merlucius productus*), the hake in turn having been swallowed by an albicore (*Orcynus alalonga*), and the latter taken on the hook, before the *Sudis* inside the hake had become digested.

The Synodontidæ or lizard-fishes, have the body elongate and nearly cylindrical, covered with scales, as are also the sides of the head. The head is lizard-like in form, the gape of the mouth very wide, and the jaws are armed with many rows of sharp teeth. The maxillary is very slender or nearly obsolete, and closely adherent to the premaxillary. This character best distinguishes the family from the Scopelidæ and other forms, in which the maxillary is well developed. The dorsal is short and median in position, and behind it is usually a well-developed adipose fin: The skeleton is more perfectly ossified than in related families.

There are about twenty species known, inhabiting the seas of warm regions; voracious fishes of little value as food. A few of them are deep-sea forms, but the most of them inhabit shallow waters, in which they lie close to the bottom, their colors often very closely imitating the coral-sand and algæ. One species, *Synodus fœtens*, is abundant on our South Atlantic coast, and others occur further southward.

The Aulopidæ are closely allied to the Synodontidæ, differing in the well-developed maxillary, and, according to Cope, in the presence of a tail vertebra. The few species are found in the Mediterranean and in the Pacific.

The Scopelidæ are also allied to the Synodontidæ, but have the maxillary well developed, the body more compressed, and in nearly every species provided with phosphorescent spots. Some fifty species are now known, most of them deep-sea fishes, although others are rather pelagic, some of them (*Myctophum*) "coming to surface at night only; during the day and in very rough weather, they descend to depths where they are safe from sunlight or the agitation of the water." (*Günther.*) Some of them may be caught in the night by a tow-net at the surface, while others are found at a depth of nearly three miles. One of the American species (*Myctophum crenulare*) is known from two specimens only, the one taken from the stomach of an albicore (*Orcynus*), in the Santa Barbara channel; the other thrown by the waves, in a storm, on board a vessel in the Strait of Juan de Fuca. The most remarkable peculiarity of the Scopelidæ and related deep-sea forms is the development of luminous spots. These are usually arranged in one or more series along the sides of the body.

Closely related to the Scopelidæ are the Ipnopidæ, consisting of the single genus *Ipnops*. In this genus the whole upper surface of the long snout is occupied by a phosphorescent organ, longitudinally divided into two symmetrical halves. This is apparently the representative of the eye, and it is thought by Dr. Günther, who first described *Ipnops murrayi*, that the eye has "lost its function of vision and assumed that of producing light."

The following account of the structure and functions of the phosphorescent spots is condensed from the chapter on deep-sea fishes in Günther's Guide to the Study of Fishes.

Many fishes of the deep sea are provided with more or less numerous round, shining, mother-of-pearl-colored bodies, imbedded in the skin. These so-called phosphor-

escent or luminous organs are either larger bodies of an ovoid shape, placed on the head, in the vicinity of the eye, or smaller globular bodies regularly arranged in series along the side of the body and tail, especially near the abdominal profile. The former have not yet been studied. Of the latter class, the number of pairs is in direct relation to that of the vertebræ, the muscular system, etc. These again are of two kinds. The organs of one kind consist of an anterior, biconvex, lens-like body, which is transparent during life, simple or composed of rods, and coated with a dark membrane composed of hexagonal cells, or of rods arranged as in a retina. This structure is found in *Astronesthes*, *Stomias*, *Chauliodus*, etc. In the other kind, the organ shows throughout a simply glandular structure, but apparently without an efferent duct (*Gonostoma*, *Myctophum*, *Maurolicus*, *Argyropelecus*). Branches of the spinal nerves run to each organ, and are distributed over the retina-like membrane or the glandular follicles. The former kind of organs are considered by some naturalists to be true organs of vision (accessory eyes).

Although these organs thus differ in structure, there is no doubt that the functions of all have some relation to the peculiar conditions of light under which the fishes provided with them live; these fishes being either deep-sea forms, or nocturnal pelagic kinds.

There are three possible hypotheses as to the function of these organs.

1. All are accessory eyes, or at least sensory in their function.

2. Only the organs with lenticular body are accessory eyes, and those with a glandular structure produce and emit phosphorescent light.

3. All are producers of light.

The first view seems very improbable. Many of the species with phosphorescent spots possess very large eyes, which would render these feeble ones unnecessary, while other species of the deep sea, having eyes concealed or imperfect, lack the luminous spots.

The second supposition seems to be nearer the truth. It is supported by the fact that the glandular organs in *Myctophum* have actually been observed to shine with "phosphorescent" light, and by the obvious similarity of the organs with lenticular body and retina-like membrane to a true eye. In depths illuminated by phosphorescent light only, we might well expect the development of peculiar organs of vision. But many fishes which inhabit great depths (Macruridæ, Trachypteridæ), have large eyes of the ordinary sort, from which it appears that the ordinary organ of vision is sufficient for seeing by phosphorescent light.

While we must admit that those compound organs may prove to be organs of sense, it is not unreasonable to suppose that they too, like the glandular organs, are producers of light. It may be produced at the bottom of the posterior chamber, and emitted through the lenticular body in particular directions, with the same effect as when light is sent through the convex glass of a "bull's eye." This hypothesis seems to be less bold than the other, which would require us to believe that vertebrate animals, with a nervous centre specialized for the reception of the impressions of the higher senses, should receive them through the spinal cord.

At present, therefore, the existence, in fishes, of 'accessory eyes' capable of receiving visual impressions, cannot be admitted as proved, although it is not impossible.

The STOMIATIDÆ are deep-sea fishes with the body naked, or covered with thin loose scales. The mouth is very large, which fact has suggested the name of the typical genus, *Stomias*, and the teeth are strong, numerous, and unequal, some of them being

usually fang-like. Unlike the Scopelidæ, the lateral margins of the upper jaw are formed by the maxillaries, which are provided with teeth. At the throat, in all the known species, is a long fleshy barbel. The opercular apparatus is incomplete, and, as usual in fishes inhabiting great depths, the skeleton is imperfectly ossified. Some of them (*Astronesthes*) have the adipose fin, but most have not. The phosphorescent spots are numerous, and, as already described, are more specialized than those found in the Scopelidæ, bearing much resemblance to true eyes. The Stomiatidæ are all comparatively small, although evidently, in their proper element, ferocious fishes. About a dozen species are now known, from the deep seas of various regions. About six species, representing the principal types, have been obtained by the 'Fish Hawk,' and the 'Albatross,' the dredging steamers of the United States Fish Commission, off our Atlantic coast. Of *Malacosteus niger*, another deep-sea type, specimens are exceedingly rare, although the genus has long been known. Its relations are still obscure.

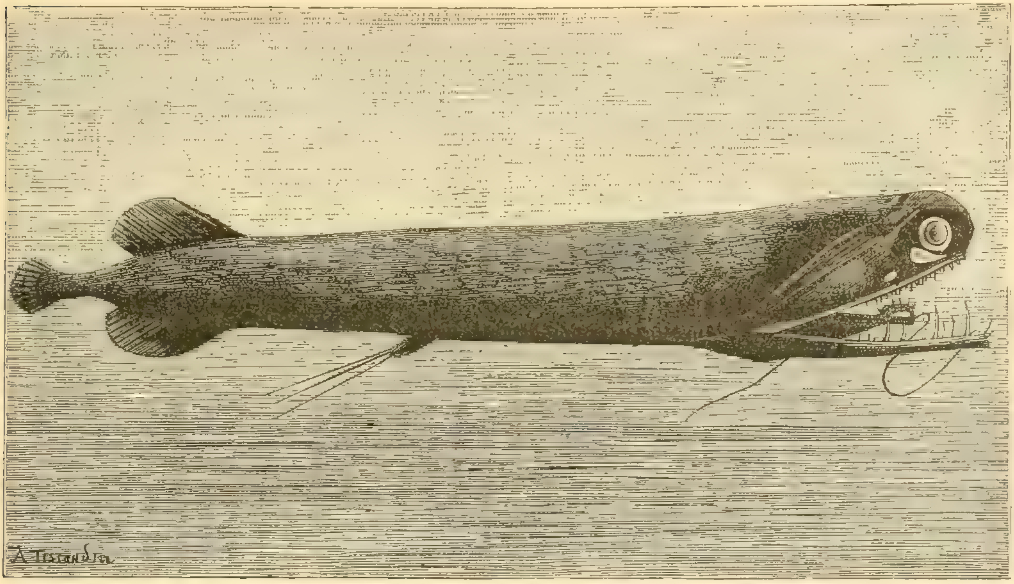


FIG. 90. — *Malacosteus niger.*

Closely related to the Stomiatidæ are the STERNOPTYCHIDÆ. These fishes have a similar structure of the mouth, but the teeth are small, and there is no barbel at the throat. The body is rather deep, naked, and covered with silvery pigment, instead of black as in the Stomiatidæ generally. The adipose fin is present. The phosphorescent spots are of the less specialized type seen in the Scopelidæ. About a dozen species are known, all small fishes, of the deep sea. It is, however, probable that they are surface fishes, descending in the daytime, rather than true members of the deep-sea fauna. Four species have been taken in the Gulf Stream, off our coasts.

The CHAULIODONTIDÆ are allied to the Sternoptychidæ, but having the body elongate, and covered with small scales. The mouth is in most cases very large, and the teeth are more or less unequal. In the typical genus, *Chauliodus*, the teeth are inordinately developed, some of them being more than one third the length of the head.

When the mouth is closed, these large teeth remain outside. The other species have smaller teeth. All of them inhabit considerable depths, and are provided with luminous spots of the complex stomiatoid type. Some of them are silvery, others black in color, the latter probably inhabiting the greater depths. *Chauliodus sloani* seems to be comparatively common in the mid-Atlantic. It has been longer known than any other species which inhabits waters so deep.

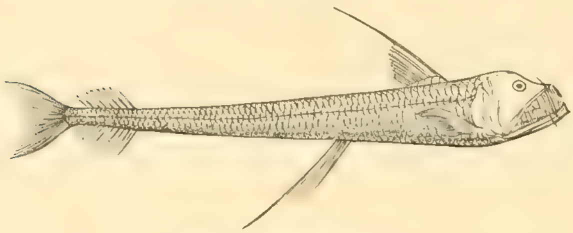


FIG. 91.— *Chauliodus sloani.*

The HALOSAURIDÆ are elongate fishes, bearing a superficial resemblance to the Macruridæ and other Anacanthine forms, which, in structure, are very different. There are no barbels; the head and body are scaly. The maxillaries form the border of the upper jaw; the teeth of the mouth are all small. There is no adipose fin; the dorsal fin is short and small, and the anal fin is very long. The tail is long and tapers to a point, there being no separate caudal fin. The species are black in color, and are provided with phosphorescent spots. Five species are known. They are apparently abundant in the depths of the Atlantic, and one of them (*Halosaurus macrochir*), has been several times taken at great depths off our coast. They reach a length of about two feet. The extinct family of HOPLOPLEURIDÆ, found in cretaceous and tertiary rocks, is placed near the Halosauridæ by Dr. Günther. In this group, the body is armed "with four series of subtriangular scutes, besides intermediate scale-like smaller ones."

The PANTODONTIDÆ comprises but a single known species (*Pantodon buchholzi*), a small, fresh-water fish from the west coast of Africa. It is said to resemble a Cyprinodont, but with the sides of the head osseous, and the subopercle and interopercle obsolete.

The NOTOPTERIDÆ are fresh-water fishes of the East Indies and western Africa. They have the body elongate, ending in a long and tapering tail. The belly has a double serrature and some of the bones of the head are also serrate. There is no adipose fin. The dorsal fin is very small or wanting, and the anal, as in the Halosauridæ, is very long. The subopercle is wanting. The teeth are small. The air bladder is highly complex in structure, being "divided into several compartments, and terminating in two horns anteriorly and posteriorly, the anterior horns being in direct connection with the auditory organ."

The OSTEOGLOSSIDÆ are large, pike-like fishes of the rivers of the tropics. The head is naked and its skin is ossified so that it is almost entirely covered by bone, somewhat as in the genus *Amia*. The scales on the body are very hard and bony, composed of pieces like mosaic. The mouth is large, but the teeth are small. The dorsal and anal are long, and placed far back, near the small caudal. The air-bladder is sometimes cellular. One genus (*Osteoglossum*) has two barbels on the lower jaw, and the edge of the abdomen is trenchant. The others have the abdomen rounded and the mouth without barbels. Six species of these remarkable fishes are known. *Arapaima gigas* inhabits the rivers of Brazil and Guiana, where it is said to reach a length of fifteen feet and a weight of four hundred pounds. It is the largest strictly fresh-water fish known, and in Brazil it has considerable economical importance as a

food-fish. The three species of *Osteoglossum* are remarkably distributed, one being found in Brazil, one in Australia, and the third in the East Indies. The single species of *Heterotis* inhabits the Nile.

The GALAXIIDÆ are small fishes, somewhat trout-like in appearance, found in New Zealand, Australia, and the southern parts of South America. The body is rather elongate, and without scales. The dorsal fin is opposite the anal, and similar to it, and there is no adipose fin. As in the Salmonidæ, there is no oviduct, the eggs falling into the cavity of the abdomen before exclusion. About twelve species are recorded, nearly half of them from New Zealand, where these fishes are most abundant, and where they are locally known as trout.

FIG. 92.—*Arapaima gigas.*

The HAPLOCHITONIDÆ are still more trout-like, differing from the Salmonidæ chiefly in the structure of the mouth, the entire margin of the upper jaw being formed by the premaxillary. Four species are known, belonging to the genera *Haplochiton* and *Prototroctes*. The former is naked, and inhabits the lakes of Tierra del Fuego and the Falkland Islands. The latter is found in Australia and New Zealand, where it is often called grayling. In *Prototroctes*, the body is scaly.

The small family of SALANGIDÆ comprises two species allied to the Argentinidæ, but with the alimentary canal straight for its whole length and without pyloric appen-

dages. The body is elongate, compressed, and naked, or covered with very fine deciduous scales. The snout is long, flat, and pointed. They are small colorless fishes living at considerable depths off the coasts of China, and Japan, approaching the shore to spawn in their season. They are considered a delicacy, and to the English in China they are known as whitebait, a name given in London to the translucent young of the herring and other clupeoid fishes.

The small family of smelt, or ARGENTINIDÆ, is separated by Dr. Gill from the Salmonidæ, with which they have many affinities, on account of the form of the stomach and its appendages. In the Salmonidæ proper the stomach is siphonal, the œsophagus and pylorus being widely separated, and about the stomach are many pyloric cœca. In the Argentinidæ, the stomach is in the form of a blind sac, the opening of the œsophagus and that of the pylorus being near together, and there are but few, if any, pyloric cœca. Externally the two families are very similar. The Argentinidæ are, however, small fishes, properly marine, while the Salmonidæ are rather fluviatile in habit. About twenty-five species are known, all but one of them inhabiting the

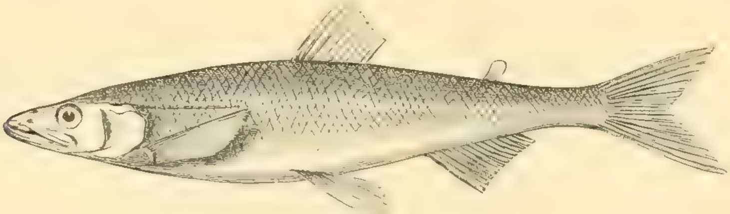


FIG. 93.—*Osmerus mordax*, smelt.

waters of the North Temperate zone, and rarely passing southward of a latitude of about forty degrees. Several of them are deep-sea fishes, while most of the others are found near the shore, ascending the rivers in the spring, to deposit their spawn. Of the anadromous species, many have a considerable economic value, as they furnish excellent food.

The genus *Retropinna*, distinguished by the backward position of its dorsal, is found in the waters of New Zealand, where its single species is known, not inappropriately, by the name of smelt. The species of *Microstoma*, *Argentina* and *Bathylagus*, are deep-sea fishes, not unfrequently taken in the Atlantic, and some of them even venturing into comparatively shallow water in the northern regions. It is a somewhat curious fact that many shore-fishes of the arctic become deep-sea fishes in the temperate zone. None of these, however, inhabit the enormous depths in which many eels, stomiatoids, etc., occur. These deep-sea Argentinidæ are silvery in color and have no phosphorescent spots.

The genus *Osmerus* contains the smelt, characterizable by the presence of strong, fang-like teeth on the tongue and on the vomer, and by the comparatively large size of the scales, which are readily deciduous. One of the species, *Osmerus eperlanus*, is common along the shores of northern Europe, where it is held in high esteem as a food-fish. Another, (*Osmerus mordax*), scarcely different from this, but with rather smaller scales, is equally abundant on the American coast from Delaware Bay northward. Both these species ascend fresh-water streams, and both in America and Europe, stunted forms are found permanently land-locked in ponds and lakes. The flesh of the smelt is rich and delicate, but it spoils quickly in warm weather. A third species (*O. thaleichthys*), very similar, but smaller in size, and feebler in dentition, is found on

the Pacific coasts of North America, and a fourth species, (*Osmerus dentex*), in the corresponding parts of Asia.

The genus *Thaleichthys* contains but a single species, the famous eulachon or candle-fish (*Thaleichthys pacificus*), of the eastern shores of the North Pacific. It differs from *Osmerus* in the feeble teeth, smaller scales, and dusky coloration. This little fish has the form of the smelt and reaches the length of nearly a foot. In the spring, it ascends in enormous numbers all the rivers north of the Columbia, for a short distance, for the purpose of spawning. These runs take place in Fraser River, in May, at the time of the best salmon runs. Various predatory fishes and sea-birds persecute the eulachon during its runs, and even the stomachs of the sturgeons are often found full of the little fishes, which they have taken in by their sucker-like mouths. At the time of the runs, the eulachon are extremely fat, so much so, that it

FIG. 94.—*Osmerus eperlanus*, European smelt, eperlan.

is said that when dried, and a wick drawn through the body, they may be used as candles. On Nass River, in British Columbia, a stream in which their run is greatest, there is a factory for the manufacture of eulachon oil from them. This delicate oil is proposed as a substitute for the cod-liver oil used in medicine. Whatever may be its merits in this regard, it has the disadvantage in respect to salability of being semi-solid or lard-like at ordinary temperatures, requiring melting to make it flow as oil. The eulachon is a favorite pan-fish in British Columbia. The writer has had considerable experience with it, broiled and fried, in its native region, and has no hesitation in declaring it to be the best flavored food-fish in American waters. It is fat, tender, juicy, and richly flavored, with comparatively few troublesome bones. It does not, however, bear transportation well.

The capelin (*Mallotus villosus*) closely resembles the eulachon, differing mainly in its broader pectorals and in the peculiar scales of the males. In the male fish, a

band of scales above the lateral line and along each side of the belly become elongate, closely imbricated, with the free points projecting, giving the region a villous appearance. It is very abundant on the coasts of arctic America, both in the Atlantic and Pacific, and is an important source of food to the natives of those regions.

The surf-smelts (*Hypomesus*) resemble the true smelt in form and coloration, but have the mouth smaller, the teeth feeble, and the ventral fins inserted further back, under the middle of the dorsal. One species (*Hypomesus pretiosus*) is found on the Pacific coast, from Monterey to Alaska. According to Mr. James G. Swan, who has published an excellent account of its habits, it has "its belly covered with a coating of yellow fat, which imparts an oily appearance to water where the fish have been cleaned or washed, and makes them the very perfection of pan-fish."

The surf-smelt comes into Puget Sound in vast numbers in late spring and summer, and are sometimes so abundant that "the water seems to be filled with them." They cast their spawn along the shore in the fjord bays. They "come in with the flood tide, and when a wave breaks on the beach, they crowd up into the very foam, and as

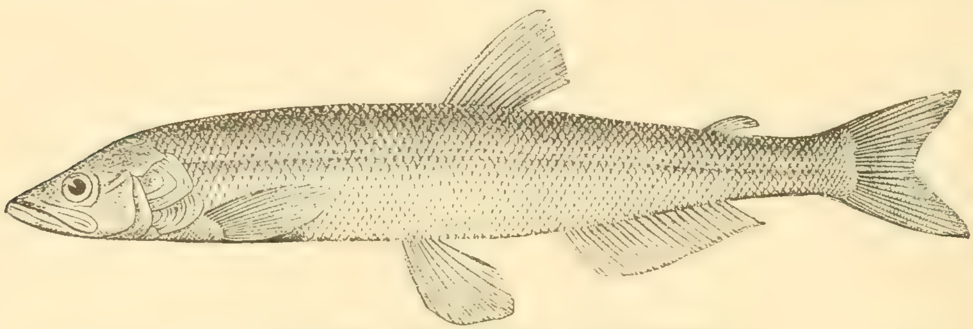


FIG. 95.— *Thaleichthys pacificus*, eulachon, candle-fish.

the surf recedes, many will be seen flapping on the sand and shingle, but invariably returning with the undertow to deeper water." The superstition is prevalent among the Quillehute Indians of Washington Territory, that the first surf-smelts "which appear must not be sold, or given away to be taken to another place, nor must they be cut transversely, but split open with a mussel-shell." This species never enters fresh waters so far as known, but farther northward, in Alaska and Kamtschatka, a second species (*Hypomesus olidus*) enters the streams and spawns in fresh-water ponds.

Of all the families of fishes, the one most interesting from almost every point of view is that of the SALMONIDÆ. As now restricted it is not one of the largest families, as it comprises less than a hundred species, but in beauty, activity, gaminess, quality as food, and even in size of individuals, different members of the group stand easily with the first among fishes. The following are the chief external characters which are common to the members of the family as here understood, the Argentinidæ and Salangidæ, usually included with them, being here placed in separate groups: Body oblong or moderately elongate, covered with cycloid scales of varying size. Head naked. Mouth terminal or somewhat inferior, varying considerably among the different species, those having the mouth largest usually having also the strongest teeth. Maxillary provided with a supplemental bone, and forming the lateral margin of the upper jaw. Pseudobranchiæ present. Gill rakers varying with the species. Opercula complete. No barbels. Dorsal fin of moderate length, placed near the middle of the length of the body. Adipose fin well developed. Caudal fin forked.

Anal fin moderate or rather long. Ventral fins nearly median in position. Pectoral fins inserted low. Lateral lines present. Outline of belly rounded.

The stomach in all the Salmonidæ is siphonal, and at the pylorus are many (15 to 200) comparatively large pyloric cœca. The air-bladder is large. The eggs are usually much larger than in fishes generally, and the ovaries are without special duct, the ova falling into the cavity of the abdomen before exclusion. The large size of the eggs, their lack of adhesiveness, and the readiness by which they may be impregnated, render the Salmonidæ peculiarly adapted for artificial culture.

The Salmonidæ are peculiar to the North Temperate and Arctic regions, and within this range they are almost equally abundant everywhere where suitable waters occur. Some of the species, especially the larger ones, are marine and anadromous, living and growing in the sea, and ascending fresh waters to spawn. Still others live in running brooks, entering lakes or the sea when occasion serves, but not habitually doing so. Still others are lake fishes, approaching the shore, or entering brooks in the spawning season, at other times retiring to waters of considerable depth. Some of them are active, voracious, and gamey, while others are comparatively defenceless, and will not take the hook. They are divisible into eight readily recognizable genera,—*Coregonus*, *Plecoglossus*, *Brachymystax*, *Stenodus*, *Thymallus*, *Oncorhynchus*, *Salmo*, and *Salvelinus*. These groups may be discussed in order.

The genus *Coregonus*, which includes the various species known in America as lake white-fish, is distinguishable in general by the small size of its mouth, the weakness of its teeth, and the large size of its scales. The teeth, especially, are either reduced to very slight asperities, or else are altogether wanting. The species reach a length of one to two feet or more. With scarcely an exception they inhabit clear lakes, and rarely enter streams except to spawn. In far northern regions they often descend to the sea, but in the latitude of the United States this is rarely possible for them, as they are unable to endure impurities in the water. They seldom take the hook, and rarely feed on other fishes. From their restriction to the waters of the different lake systems in which they live, numerous local varieties have come about both in Europe and America, distinguished by characters less constant and less important than those which separate the different species. European writers have somewhat inconsistently regarded these varying and intangibly different forms as distinct species, and many of them have come to the conclusion that almost every lake system of Scandinavia, Scotland, and Russia has several species which are peculiar to it. Dr. Günther observes that "the species of this genus are not less numerous than those of *Salmo*, some having a very extended geographical range, whilst others are confined to very limited localities. They are less subject to variation than the trout, and therefore more easily characterized and distinguished. Hence we find that naturalists who look with distrust on the different species of *Salmo* are quite ready to admit those of *Coregonus*." In my experience, the variableness in *Coregonus* has been underestimated, and the American species at least are all fishes of wide range, varying considerably with their surroundings. None of the other species reach the size, or have the value as food, of our common white-fish.

The species differ considerably in the form and size of the mouth, in the form of the body, and in the development of the gill-rakers. These differences have led to the establishment of about five sections, or subgenera, the extremes of which differ remarkably, but which gradually pass from one into another. Of the species, the following are among the most noteworthy. *Coregonus oxyrhynchus*, the Schnäpel of Holland

Germany, and Scandinavia, has the mouth very small, the sharp snout projecting far beyond it. No species similar to this is found in America. The Rocky Mountain white-fish (*Coregonus williamsoni*) has also a small mouth and projecting snout, but the latter is blunter and much shorter than in *C. oxyrhynchus.* This is a small species abounding everywhere in the clear lakes of the Rocky Mountains and the Sierra Nevada, from Colorado to Vancouver Island. It is a handsome fish, and excellent as food.

Closely allied to *C. williamsoni* is the pilot-fish, shad-waiter, round-fish, or Menomonee white-fish, *Coregonus quadrilateralis.* This species is found in the great lakes, the Adirondack region, the lakes of New Hampshire, and thence northwestward to Alaska, abounding in cold, deep waters, its range apparently nowhere coinciding with that of *C. williamsoni.* The common white-fish (*C. clupeiformis*) is the largest in size of the species of *Coregonus*, and is unquestionably the finest as an article of food.

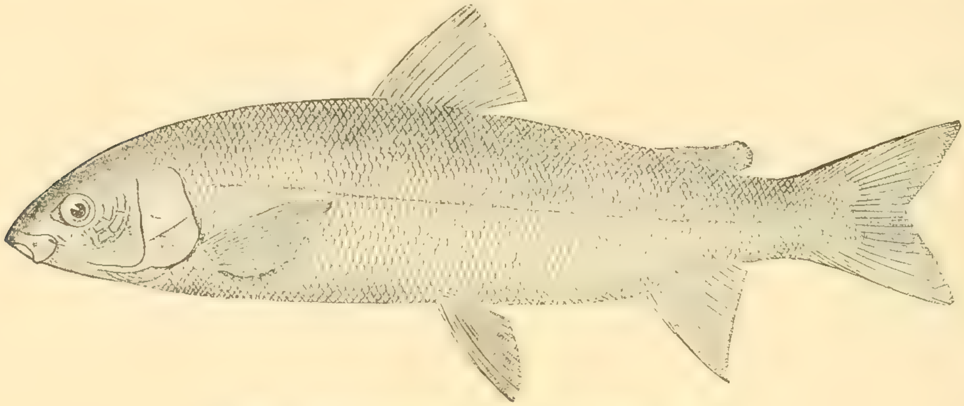


FIG. 96. — *Coregonus williamsoni*, Rocky Mountain white-fish.

It varies considerably in appearance with age and condition, but in general it is proportionately much deeper than any of the other small-mouthed *Coregoni.* The adult fishes develop a considerable fleshy lump at the shoulders, which causes the head, which is very small, to appear disproportionately so.

The white-fish spawns in November and December on rocky shoals in the great lakes. Its food, which was for a long time unknown, was ascertained by Dr. P. R. Hoy to consist chiefly of deep-water crustaceans, with a few molluscs, and larvæ of water insects. "The white-fish," writes Mr. James W. Milner, "has been known since the time of the earliest explorers as pre-eminently a fine-flavored fish. In fact there are few table-fishes its equal. To be appreciated in its fullest excellence, it should be taken fresh from the lake and broiled. Father Marquette, Charlevoix, Sir John Richardson, explorers who for months at a time had to depend on the white-fish for their staple article of food, bore testimony to the fact that they never lost their relish for it, and deemed it a special excellence that the appetite never became cloyed with it." The range of the white-fish extends from the lakes of New York and New England northward to the Arctic Circle. The 'Otsego bass,' of Otsego Lake in New York, celebrated by De Witt Clinton, is the ordinary white-fish.

Allied to the American white-fish, but smaller in size, is the lavaret, Weissfisch, Adelfisch, or Weissfelchen (*Coregonus lavaretus*), of the mountain lakes of Switzerland, Germany, and Sweden. Several other related species occur in northern Europe and Siberia.

Another American species is the lake whiting or Musquaw River white-fish (*Coregonus labradoricus*). Its teeth are stronger, especially on the tongue, than in any of our other species, and its body is slenderer than that of the white-fish. It is found in the upper great lakes, in the Adirondack region, in Lake Winnepisaukee, and in the lakes of Maine and New Brunswick. It is said to rise to the fly in the Canadian lakes.

The smallest and handsomest of the American white-fish is the cisco of Lake Michigan (*Coregonus hoyi*). It is a slender fish, rarely exceeding ten inches in length, and its scales have the brilliant silvery lustre of *Hyodon* or *Albula*. The lake herring, or cisco (*Coregonus artedii*), is, next to the white-fish, the most important of the American species. It is more elongate than the others, and has a comparatively large mouth, with projecting under jaw. They are more voracious, and often take the hook. During the spawning season of the white-fish, they feed on the ova of the latter, thereby doing a great amount of mischief. As food, this species is fair, but much inferior to the white-fish. Its geographical distribution is essentially the same, but to a greater degree it frequents shoal waters.

In the small lakes around Lake Michigan (Tippecanoe, Geneva, Oconomowoc, etc.), the cisco has long been established, and in these its habits have undergone some change, as well as its external appearance. These lake ciscoes remain for most of the year in the depths of the lake, coming to the surface only in search of certain insects, and to shallow water only in the spawning season. This periodical disappearance of the cisco has led to much nonsensical discussion as to the probability of their returning by an underground passage to Lake Michigan during the periods of their absence. The name lake herring alludes to the superficial resemblance which this species possesses to the marine herring, a fish of quite a different family.

Closely allied to the lake herring is the blue-fin of Lake Michigan (*Coregonus nigripinnis*), a fine large species inhabiting deep waters, and recognizable by the blue-black color of its lower fins. In Alaska and Siberia are still other species of the cisco type (*C. laurettæ*, *C. merki*, *C. nelsoni*), and in Europe very similar species are the Scotch vendace (*C. vandesius*), and the Scandinavian Loke-Sild (lake herring), as well as others less perfectly known.

The tullibee, or mongrel white-fish (*Coregonus tullibee*), has a deep body, like the shad, with the large mouth of the ciscoes. Fishermen think it a hybrid between *C. clupeiformis* and *C. artedii*. It is found in the great lake region and northward, and very little is known of its habits. A similar species (*C. cyprinoides*) is recorded from Siberia, a region which is peculiarly suited for the growth of the *Coregoni*.

Allied to the *Coregoni* is *Plecoglossus altivelis*, a small fish of the waters of Japan and Formosa, which has small, compressed, serrated, movable teeth in the jaws. This is said to be an annual fish, the life of each individual ceasing at the end of the season of reproduction.

Another little known form, intermediate between the white-fish and the salmon, is *Brachymystax lenok*, a large fish of the mountain streams of Siberia. Only the skins brought home by Pallas, about a century ago, seem to be known as yet. According to Pallas, it sometimes reaches a weight of eighty pounds. Still another genus, intermediate between the white-fish and the salmon, is *Stenodus*, distinguished by its elongate body, feeble teeth, and projecting lower jaw. The inconnu, or Mackenzie River salmon (*Stenodus mackenzii*), belongs to this genus. It reaches a weight of twenty pounds or more, and in the far north is a food fish of good quality. Little is

recorded of its habits, and few specimens exist in museums. Species of *Stenodus* are said to inhabit the Volga, Obi, Lena, and other northern rivers, but as yet little definite is known of them.

The grayling (*Thymallus*) termed by St. Ambrose "the flower of fishes," is likewise intermediate between the white-fish and the trout, having larger scales than the latter, and feebler teeth. The teeth on the tongue, found in all the trout and salmon, are in the grayling obsolete. The chief distinctive peculiarity of the genus *Thymallus* is the great development of the dorsal fin, which has more rays (20 to 24) than in any other of the Salmonidæ, and the fin is also higher. All the species are gayly colored, the dorsal fin especially being marked with purplish or greenish bands, and

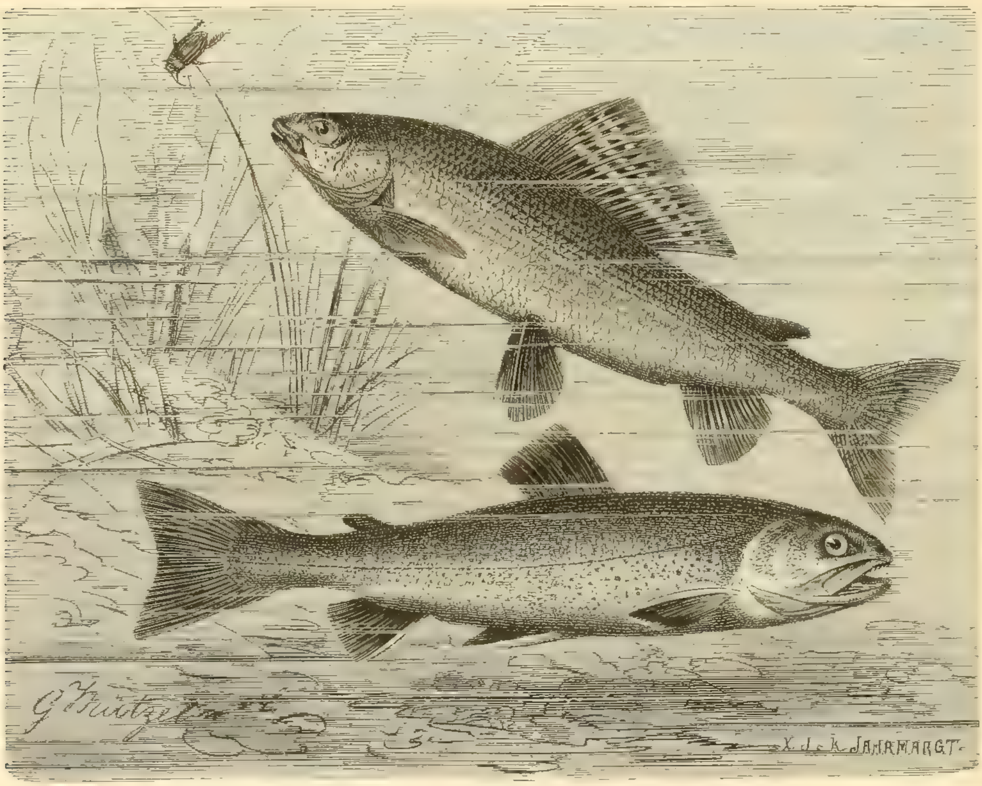


FIG. 97.— *Thymallus thymallus*, grayling, and *Salvelinus alpinus*, red charr.

bright rose-colored spots; while the body is mostly purplish-gray, often with black spots. Most of the species rarely exceed a foot in length, but northward they grow larger. Grayling weighing five pounds have been taken in England, and according to Dr. Day, they are said, in Lapland, to reach a weight of eight or nine pounds.

The grayling, in all countries, frequents clear, cold brooks, and rarely, if ever, enters the sea or even the larger lakes. They are said to congregate in small shoals in the streams, and to prefer those which have a succession of pools and shallows, with a sandy or gravelly, rather than a rocky bottom. It spawns on the shallows in April or May (in England), and is said to be non-migratory in its habits, depositing its ova in the neighborhood of its usual haunts. The ova are said to be far more delicate and easily killed than those of the trout or charr.

The grayling and the trout often inhabit the same waters, but not altogether in harmony. It is said that the grayling devours the eggs of the trout. It is certain that the trout feed on the young grayling. As a food-fish the grayling, of course, ranks high; but the true sportsman will hardly seek such fish as these to fill his frying-pan. They are considered gamey fishes, although less strong than the brook-trout, and perhaps less wary. The five or six known species of grayling are very closely related, and are doubtless comparatively recent offshoots from a common stock, which has now spread itself widely through the northern regions.

The common grayling of Europe (*Thymallus thymallus*), found throughout northern Europe, and as far southward in the mountains as Hungary and northern Italy. The name *Thymallus* was given by the ancients, because the fish, when fresh, had the odor of water thyme, an odor which the duller sense of the moderns now fails to detect. Other species are described from Russia and Siberia.

The American grayling (*Thymallus signifer*), is widely distributed in British America and Alaska. In several streams in northern Michigan and in Montana occurs another form, known to anglers as the Michigan grayling (*Thymallus ontariensis*). This variety or species has a longer head, smaller scales, and the dorsal fin rather lower than in the northern form (*signifer*), but the constancy of these characters in specimens from intermediate localities is yet to be tested. It is probable that the grayling once had a wider range to the southward than now, and that so far as the waters of the United States are concerned, it is tending towards extinction. This tendency is of course being accelerated in Michigan by lumbermen and anglers.

The genus *Oncorhynchus* contains those species of Salmonidæ which have the greatest size and value. They are in fact, as well as in name, the king salmon. The genus is closely related to *Salmo*, with which it agrees in general as to the structure of its vomer, and from which it disagrees in the increased number of anal rays, branchiostegals, pyloric cœca and gill-rakers. The character most convenient for distinguishing *Oncorhynchus*, young or old, from all the species of *Salmo*, is the number of developed rays in the anal fin. These, in *Oncorhynchus* are thirteen to twenty, in *Salmo* nine or ten.

The species of *Oncorhynchus* have long been known as anadromous salmon, confined to the North Pacific. The species were first made known one hundred and thirty years ago, by that most exact of early observers, Steller, who described and distinguished them with perfect accuracy, and gave them, as vernacular names, the Russian names which now stand in scientific nomenclature for the different species.

Since Steller's time, writers of all degrees of incompetence, and writers with scanty material, or with no material at all, have done their worst to confuse our knowledge of these salmon, until it became evident that no exact knowledge of any of the species remained. In the current system of a few years ago, the males of the five species known to Steller constituted a separate genus of many species, while the females were placed in the genus *Salmo*, and the young formed still other species of a third genus, called *Fario*. Not one of the writers on these fishes of twenty-five years ago knew a single species definitely, at sight, or used knowingly in their descriptions a single character by which species are really distinguished. Not less than thirty-five nominal species of *Oncorhynchus* have already been described from the North Pacific, although, so far as is now known, only the five originally noticed by Steller really exist. The descriptive literature of the Pacific salmon is among the very worst extant in science. This is not, however, altogether the fault of the authors, but it is

in great part true to the extraordinary variability in appearance of the different species of salmon. These variations are, as will be seen, due to several different causes, notably to differences in surroundings, in sex, and in age.

The writer and his associate, Professor Charles H. Gilbert, have had, under the auspices of the United States Fish Commission, better opportunities to study the different species of *Oncorhynchus* than have fallen to the lot of any other ichthyologists. The following discussion of the different species is condensed from our report to the U. S. Census Bureau, portions of which were published in the American Naturalist for March, 1881. Similar conclusions have been independently reached by Dr. T. H. Bean, who visited Alaska in 1880.

There are five species of salmon (*Oncorhynchus*) in the waters of the North Pacific. We have at present no evidence of the existence of any more on either the American or the Asiatic side.

These species may be called the quinnat or king salmon, the blue-black salmon or red fish, the silver salmon, the dog salmon, and the hump-back salmon, or *Oncorhynchus tchawytcha*, *nerka*, *kisutch*, *keta*, and *gorbuscha*. All these species are now known to occur in the waters of Kamtschatka as well as in those of Alaska and Oregon.

FIG. 98. *Oncorhynchus tchawytcha*, young male quinnat or king salmon.

These species, in all their varied conditions, may usually be distinguished by the characters given below. Other differences of form, color, and appearance are absolutely valueless for distinction, unless specimens of the same age, sex, and condition are compared.

The quinnat salmon (*Oncorhynchus tchawytcha*) has an average weight of 22 pounds, but individuals weighing 70 to 100 pounds are occasionally taken. It has about 16 anal rays, 15 to 19 branchiostegals, 23 (9+14) gill rakers on the anterior gill arch, and 140 to 185 pyloric cœca. The scales are comparatively large, there being from 130 to 155 in a longitudinal series. In the spring the body is silvery, the back, dorsal fin, and caudal fin having more or less of round black spots, the sides of the head having a peculiar tin-colored metallic lustre. In the fall the color is often black or dirty-red, and the species can only be certainly distinguished by its technical characters.

The blue-back salmon (*Oncorhynchus nerka*) usually weighs from 5 to 8 pounds. It has about 14 developed anal rays, 14 branchiostegals, and 75 to 95 pyloric cœca. The gill rakers are more numerous than in any other salmon, the number being usually about 39 (16+23). The scales are large, there being 130 to 140 in the lateral line. In the

spring the form is plumply rounded, and the color is a clear bright blue above, silvery below, and everywhere immaculate. Young fishes often show a few round black spots, which disappear when they enter the sea. Fall specimens in the lakes are bright red in color, hook-nosed and slab-sided, and bear little resemblance to the spring run. Young spawning male grilse are also peculiar in appearance, and were for a time considered as forming a distinct "genus" under the name of "*Hypsifario kennerlyi*."

The silver salmon (*Oncorhynchus kisutch*) reaches a weight of 3 to 8 pounds. It has 13 developed rays in the anal, 13 branchiostegals, 23 (10+13) gill rakers, and 45 to 80 pyloric cœca. There are about 127 scales in the lateral line. In color it is silvery in spring, greenish above, and with a few faint black spots on the upper parts only. In the fall the males are mostly of a dirty red.

The dog salmon (*Oncorhynchus keta*) reaches an average weight of about 12 pounds. It has about 14 anal rays, 14 branchiostegals, 24 (9+15) gill rakers, and 140 to 185 pyloric cœca. There are about 150 scales in the lateral line. In spring it is dirty silvery, immaculate or sprinkled with small black specks, the fins dusky. In the fall the male is brick-red or blackish, and its jaws are greatly distorted.

The hump-back salmon (*Oncorhynchus gorbuscha*) is the smallest of the species, weighing from three to six pounds. It has usually 15 anal rays, 12 branchiostegals, 28 (13+15) gill rakers, and about 180 pyloric cœca. Its scales are much smaller than in any other salmon, there being 180 to 240 in the lateral line. In color it is bluish above, silvery below, the posterior and upper parts with many round black spots. The males in fall are red, and are more extravagantly distorted than in any other of the Salmonidæ.

Of these species, the blue-back predominates in Frazer River, the silver salmon in Puget Sound, the quinnat in the Columbia and the Sacramento, and the silver salmon in most of the streams along the coast. All the species have been seen by us in the Columbia and in Frazer River; all but the blue-back in the Sacramento and in waters tributary to Puget Sound. Only the quinnat has been noticed south of San Francisco, and its range has been traced as far as Ventura River. Of these species, the quinnat and blue-back salmon habitually 'run' in the spring, the others in the fall. The usual order of running in the rivers is as follows: *nerka*, *tchawytcha*, *kisutch*, *gorbuscha*, *keta*.

The economic value of the spring-running salmon is far greater than that of the other species, because they can be captured in numbers when at their best, while the others are usually taken only after deterioration.

The habits of the salmon in the ocean are not easily studied. Quinnat and silver salmon of every size are taken with the seine at almost any season in Puget Sound. The quinnat takes the hook freely in Monterey Bay, both near the shore and at a distance of six or eight miles out. We have reason to believe that these two species do not necessarily seek great depths, but probably remain not very far from the mouth of the rivers in which they were spawned.

The blue-back and the dog salmon probably seek deeper water, as the former is seldom or never taken with the seine in the ocean, and the latter is known to enter the Strait of Fuca at the spawning season, therefore coming in from the open sea.

The great majority of the quinnat salmon, and nearly all the blue-back salmon, enter the rivers in the spring. The run of both begins generally the last of March; it lasts, with various modifications and interruptions, until the actual spawning season in November; the time of running and the proportionate amount of each of the subor-

dinate runs varying with each different river. In general, the runs are slack in the summer and increase with the first high water of autumn. By the last of August only straggling blue-backs can be found in the lower course of any stream, but both in the Columbia and the Sacramento the quinnat runs in considerable numbers till October at least. In the Sacramento the run is greatest in the fall, and more run in the summer than in spring. In the Sacramento and the smaller rivers southward, there is a winter run, beginning in December. The spring salmon ascend only those rivers which are fed by the melting snows from the mountains, and which have sufficient volume to send their waters well out to sea.

Those salmon which run in the spring are chiefly adults (supposed to be at least three years old). Their milt and spawn are no more developed than at the same time in others of the same species which will not enter the rivers until fall. It would appear that the contact with cold fresh water, when in the ocean, in some way cause them to turn toward it and to 'run' before there is any special influence to that end exerted by the development of the organs of generation.

High water on any of these rivers in the spring is always followed by an increased run of salmon. The canners think, and this is probably true, that salmon which would not have run till later are brought up by the contact with the cold water. The cause of this effect of cold fresh water is not understood. We may call it an instinct of the salmon, which is another way of expressing our ignorance. In general, it seems to be true that in those rivers and during those years when the spring run is greatest, the fall run is least to be depended on.

As the season advances, smaller and younger salmon of these two species (quinnat and blue-back) enter the rivers to spawn, and in the fall these young specimens are very numerous. We have thus far failed to notice any gradations in size or appearance of these young fish by which their ages could be ascertained. It is, however, probable that some of both sexes reproduce at the age of one year. In Frazer River, in the fall, quinnat male grilse of every size, from eight inches upwards, were running, the milt fully developed, but usually not showing the hooked jaws and dark colors of the older males. Females less than eighteen inches in length were rare. All, large and small, then in the river, of either sex, had the ovaries or milt well developed.

Little blue-backs of every size down to six inches are also found in the upper Columbia in the fall, with their organs of generation fully developed. Nineteen twentieths of these young fish are males, and some of them have the hooked jaws and red color of the old males.

The average weight of the quinnat in the Columbia, in the spring, is twenty-two pounds; in the Sacramento about sixteen. Individuals weighing from forty to sixty pounds are frequently found in both rivers, and some as high as eighty pounds are reported. It is questioned whether these large fishes are those which, of the same age, have grown more rapidly; those which are older, but have, for some reason, failed to spawn; or those which have survived one or more spawning seasons. All of these origins may be possible in individual cases; we are, however, of the opinion that the majority of these large fish are those which have hitherto run in the fall, and so may have survived the spawning season previous.

Those fish which enter the rivers in the spring continue their ascent until death or the spawning season overtakes them. Probably none of them ever return to the ocean, and a large proportion fail to spawn. They are known to ascend the Sacramento to its extreme head-waters, about four hundred miles. In the Columbia they

are known to ascend as far as the Bitter Root Mountains, and as far as the Spokane Falls, and their extreme limit is not known. This is a distance of six to eight hundred miles.

At these great distances, when the fish have reached the spawning grounds, besides the usual changes of the breeding season, their bodies are covered with bruises, on which patches of white fungus develop. The fins become mutilated, their eyes are often injured or destroyed; parasitic worms gather in their gills, they become extremely emaciated, their flesh becomes white from the loss of the oil, and as soon as the spawning act is accomplished, and sometimes before, all of them die. The ascent of the Cascades and the Dalles probably causes the injury or death of a great many salmon.

When the salmon enter the river they refuse bait, and their stomachs are always found empty and contracted. In the rivers they do not feed, and when they reach the spawning grounds, their stomachs, pyloric cœca and all, are said to be no larger than one's finger. They will sometimes take the fly, or a hook baited with salmon roe, in the clear waters of the upper tributaries, but there is no other evidence known to us that they feed when there. Only the quinnat and blue-back (then called red-fish) have been found in the fall at any great distance from the sea.

The spawning season is probably about the same for all the species. It varies for all in different rivers, and in different parts of the same river, and doubtless extends from July to December. The manner of spawning is probably similar for all the species, but we have no data for any except the quinnat. In this species the fish pair off; the male, with tail and snout, excavates a broad, shallow 'nest' in the gravelly bed of the stream, in rapid water, at a depth of one to four feet; the female deposits her eggs in it, and, after the exclusion of the milt, they cover them with stones and gravel. They then float down the stream tail foremost. A great majority of them die. In the head-waters of the large streams, unquestionably, all die; in the small streams, and near the sea, an unknown percentage probably survive. The young hatch in about sixty days, and most of them return to the ocean during the high water of the spring.

The salmon of all kinds in the spring are silvery, spotted or not according to the species, and with the mouth about equally symmetrical in both sexes.

As the spawning season approaches, the female loses her silvery color, becomes more slimy, the scales on the back partly sink into the skin, and the flesh changes from salmon red and becomes variously paler, from the loss of the oil; the degree of paleness varying much with individuals and with inhabitants of different rivers.

In the lower Sacramento the flesh of the quinnat in either spring or fall is rarely pale. In the Columbia, a few with pale flesh are sometimes taken in spring, and a good many in the fall. In Frazer River the fall run of the quinnat is nearly worthless for canning purposes, because so many are white meated. In the spring very few are white meated, but the number increases towards fall, when there is every variation, some having red streaks running through them, others being red toward the head and pale toward the tail. The red and pale ones cannot be distinguished externally, and the color is dependent neither on age nor sex. There is said to be no difference in the taste, but there is no market for canned salmon not of the conventional orange color.

As the season advances, the difference between the males and females become more and more marked, and keep pace with the development of the milt, as is shown by dissection.

The males have: (*a.*) The premaxillaries and the tip of the lower jaw more and more prolonged, both of them becoming finally strongly and often extravagantly hooked, so that either they shut by the side of each other like shears, or else the mouth cannot be closed. (*b.*) The front teeth become very long and canine-like, their growth proceeding very rapidly, until they are often half an inch long. (*c.*) The teeth on the vomer and tongue often disappear. (*d.*) The body grows more compressed and deeper at the shoulders, so that a very distinct hump is formed; this is more developed in *O. gorbuscha*, but is found in all. (*e.*) The scales disappear, especially on the back, by the growth of spongy skin. (*f.*) The color changes from silvery to various shades of black and red, or blotchy, according to the species. The blue-back turns rosy red, the dog salmon a dull, blotchy red, and the quinnat generally blackish.

These distorted males are commonly considered worthless, rejected by the canners and salmon-salters, but preserved by the Indians. These changes are due solely to influences connected with the growth of the testes. They are not in any way due to the action of fresh water. They take place at about the same time in the adult males of all species, whether in the ocean or in the rivers. At the time of the spring runs, all are symmetrical. In the fall, all males, of whatever species, are more or less distorted. Among the dog salmon, which run only in the fall, the males are hook-jawed and red-blotched when they first enter the Strait of Fuca from the outside. The humpback, taken in salt water about Seattle, have the same peculiarities. The male is slab-sided, hook-billed, and distorted, and is rejected by the canners. No hook-jawed females of any species have been seen. It is not positively known that any hook-jawed male survives the reproductive act. If any do, their jaws must resume the normal form.

On first entering a stream the salmon swim about as if playing; they always head towards the current, and this 'playing' may be simply due to facing the flood-tide. Afterwards they enter the deepest parts of the stream and swim straight up, with few interruptions. Their rate of travel on the Sacramento is estimated by Stone at about two miles per day; on the Columbia at about three miles per day.

As already stated, the economic value of any species depends in great part on its being a 'spring salmon.' It is not generally possible to capture salmon of any species in large numbers until they have entered the rivers, and the spring salmon enter the rivers long before the growth of the organs of reproduction has reduced the richness of the flesh. The fall salmon cannot be taken in quantity until their flesh has deteriorated; hence the 'dog salmon' is practically almost worthless, except to the Indians, and the hump-back salmon is little better. The silver salmon, with the same breeding habits as the dog salmon, is more valuable, as it is found in Puget Sound for a considerable time before the fall rains cause the fall runs, and it may be taken in large numbers with seines before the season for entering the rivers. The quinnat salmon, from its great size and abundance, is more valuable than all other fishes on our Pacific coast together. The blue-back, similar in flesh, but much smaller and less abundant, is worth much more than the combined value of the three remaining species.

The fall salmon of all species, but especially the dog salmon, ascend streams but a short distance before spawning. They seem to be in great anxiety to find fresh water, and many of them work their way up little brooks only a few inches deep, where they soon perish miserably, floundering about on the stones. Every stream, of whatever kind, has more or less of these fall salmon.

It is the prevailing impression that the salmon have some special instinct which

leads them to return to spawn in the same spawning grounds where they were originally hatched. We fail to find any evidence of this in the case of the Pacific coast salmon, and we do not believe it to be true. It seems more probable that the young salmon, hatched in any river, mostly remain in the ocean within a radius of twenty, thirty, or forty miles of its mouth. These, in their movements about in the ocean, may come into contact with the cold waters of their parent rivers, or, perhaps, of any other river, at a considerable distance from the shore. In the case of the quinnat and the blue-back, their 'instinct' leads them to ascend these fresh waters, and in a majority of cases these waters will be those in which the fishes in question were originally spawned. Later in the season the growth of the reproductive organs leads them to approach the shore and search for fresh waters, and still the chances are that they may find the original stream. But undoubtedly many fall salmon ascend, or try to ascend, streams in which no salmon was ever hatched. In little brooks about Puget Sound, where the water is not three inches deep, dead or dying salmon are often found, which have entered them for the purpose of spawning.

It is said of the Russian River and other California rivers, that their mouths, in the time of low water in summer, generally become entirely closed by sand-bars, and that the salmon, in their eagerness to ascend them, frequently fling themselves entirely out of water on the beach. But this does not prove that the salmon are guided by a marvellous geographical instinct which leads them to their parent river. The waters of Russian River soak through these sand-bars, and the salmon 'instinct,' we think, leads them merely to search for fresh waters.

This matter is much in need of further investigation; at present, however, we find no reason to believe that the salmon enter the Rogue River simply because they were spawned there, or that a salmon hatched in the Clackamas River is any more likely, on that account, to return to the Clackamas than to go up the Cowlitz or the Des Chûtes.

"At the hatchery on Rogue River, the fish are stripped, marked, and set free, and every year since the hatchery has been in operation some of the marked fish have been re-caught. The young fry are also marked, but none of them have been re-caught."

In regard to the diminution of the number of salmon on the coast: In Puget Sound, Frazer River, and the smaller streams, there appears to be little or no evidence of this. In the Columbia River the evidence appears somewhat conflicting. The catch in 1880 was considerably greater than ever before (nearly 540,000 cases of 48 pounds each having been packed), although the fishing for three or four years has been very extensive. On the other hand, the high water of that year undoubtedly caused many fish to become spring salmon which would otherwise have run in the fall. Moreover, it is urged that a few years ago, when the number caught was about half as great as in 1880, the amount of netting used was perhaps one eighth as much. With a comparatively small outfit the canners caught half the fish; now, with nets much larger and more numerous, they catch them all, scarcely any escaping during the fishing season (April 1 to August 1). Whether an actual reduction in the number of fish running can be proven or not, there can be no question that the present rate of destruction of the salmon will deplete the river before many years. A considerable number of quinnat salmon run in August and September, and some stragglers even later; these now are all which keep up the supply of fish in the river. The non-molestation of this fall run, therefore, does something to atone for the almost total destruction of the spring run. This, however, is insufficient. A well-ordered salmon hatchery is the only means by which the destruction of the salmon in the river can be prevented.

The fact that the humpback salmon runs only on alternate years in Puget Sound (1875, 1877, 1879, etc.) is well attested and at present unexplained. Stray individuals only are taken in other years. This species has a distinct 'run,' in the United States, only in Puget Sound, although individuals (called 'lost salmon') are occasionally taken in the Columbia and in the Sacramento.

Numerous attempts have been made to introduce the quinnat salmon into the waters of the eastern states and of Europe. Individuals thus planted have been taken in several different localities, but, as yet, not in any considerable number.

The genus *Salmo* comprises those forms of salmon and trout which have been best and longest known. As in related genera, the mouth is large, and the jaws, palatines, and tongue are armed with strong teeth. The vomer is flat, its shaft not depressed below the level of the head or chevron (the anterior end). There are a few teeth on the chevron; and behind it, on the shaft, there is either a double series of teeth or an irregular single series. These teeth, in the true salmon, disappear with age, but in the others (the black-spotted trout), they are persistent. The scales are silvery, and moderate or small in size. There are nine to eleven developed rays in the anal fin. The caudal fin is truncate, or variously concave or forked. There are usually 40 to 70 pyloric cœca; 11 or 12 branchiostegals, and about 20 (8 + 12) gill rakers. The sexual peculiarities are in general less marked than in *Oncorhynchus*; they are also greater in the anadromous species than in those which inhabit fresh waters. In general, the male in the breeding season is redder, its jaws are prolonged, the front teeth enlarged, the lower jaw turned upwards at the end, and the upper jaw notched, or sometimes even perforated, by the tip of the lower. All the species of *Salmo* (like those of *Oncorhynchus*) are more or less spotted with black.

Two species (salmon) are marine and anadromous, taking the place, in the North Atlantic, occupied in the North Pacific by the species of *Oncorhynchus*. The others (trout), forming the sub-genus *Salar*, are non-migratory, or, at least, irregularly or imperfectly anadromous. They abound in all streams of northern Europe, northern Asia, and that part of North America which lies west of the Mississippi valley. The black-spotted trout are entirely wanting in eastern America, a remarkable fact in geographical distribution, perhaps explainable only on the hypothesis of the comparatively recent and Eurasiatic origin of the group, which we may suppose has not yet had time to extend its range across the plains, unsuitable for salmonoid life, which separate the upper Missouri from the great lakes.

The salmon (*Salmo salar*) is the only black-spotted salmonoid found in American waters tributary to the Atlantic. In Europe, where other species similarly colored occur, the species may be best distinguished by the fact that the teeth on the shaft of its vomer mostly disappear with age. From the only other species positively known (*Salmo trutta*) which shares this character, the true salmon may be known by the presence of but about eleven scales between the adipose fin and the lateral line, while *Salmo trutta* has about fourteen. The scales are comparatively large in the salmon, there being about 125 in the lateral line. The caudal fin, which is forked in the young, becomes, as in other species of salmon, more or less truncate with age. The pyloric cœca are fifty to sixty in number.

The following account of the coloration of the salmon is from Dr. Day's fishes of Great Britain: — "Color in adults superiorly of a steel blue, becoming lighter on the sides and beneath. Mostly a few rounded or x-shaped spots scattered above the lateral line and upper half of the head, being more numerous in the female than in the

male. Dorsal, caudal, and pectoral fins dusky; ventrals and anal white, the former grayish internally. Prior to entering fresh waters these fish are of a brilliant steel blue along the back, which becomes changed to a muddy tinge when they enter rivers. After these fish have passed into the fresh waters for the purpose of breeding, numerous orange streaks appear in the cheeks of the male, and also spots or even marks of the same, and likewise of a red color, on the body. It is now termed a 'red-fish.' The female, however, is dark in color, and known as 'black-fish.' 'Smolts' (young river

FIG. 99.— *Salmo salar*, salmon, male, and *S. trutta*, sea trout or salmon trout.

fish), are bluish along the upper half of the body, silvery along the sides, due to a layer of silvery scales being formed over the trout-like colors, while they have darker fins than the yearling 'pink;' but similar bands and spots, which can be seen (as in the parr) if the example be held in certain positions of light. 'Parr' (fishes of the year) have two or three black spots only on the opercle, and black spots and also orange ones along the upper half of the body, and no dark ones below the lateral line, although there may be orange ones which can be seen in its course. Along the side of the body are a series (12 to 15) of transverse bluish bands, wider than the ground color, and

crossing the lateral line, while in the upper half of the body the darker color of the back forms an arch over each of these bands, a row of spots along the middle of the rayed dorsal fin and the adipose orange-tipped."

The dusky cross-shades found in the young salmon or parr are characteristic of the young of all Salmonidæ, except, perhaps, the species of *Coregonus*.

The salmon of the Atlantic is, as already stated, an anadromous fish, spending most of its life in the sea, and entering the streams in the fall for purposes of reproduction. The time of running varies much in different streams and also in different countries. As with the Pacific species, they are not easily discouraged in their progress, leaping cascades and other obstructions, or, if these prove impassable, dying after repeated fruitless attempts.

The young salmon known as the parr is hatched in the spring. It usually remains about two years in the rivers, descending at about the third spring to the sea, when it is known as smolt. In the sea it grows much more rapidly, and becomes more silvery in color, and is known as 'grilse.' The grilse rapidly develop into the adult salmon, and some of them, as is also the case with the grilse of the Pacific salmon, are capable of reproduction.

After spawning, the salmon are very lean and unwholesome in appearance, as in fact. They are then known as kelts. The Atlantic salmon does not ascend rivers to any such distances as those traversed by the quinnat and the blue-back. Its kelts, therefore, for the most part, survive the act of spawning. Dr. Day thinks that they feed upon the young salmon in the rivers, and that, therefore, the destruction of the kelts might increase the supply of salmon. This matter needs further investigation.

As a food-fish, the Atlantic salmon is very similar to the Pacific species, neither better nor worse, so far as I can see, when equally fresh. In both, the flesh is rich and finely-flavored, but the appetite becomes cloyed with salmon-flesh sooner than with that of white-fish, smelt, or charr.

In size the Atlantic salmon does not fall far short of the quinnat. The average weight of the adult is probably less than fifteen pounds. The largest one of which I find a record was taken on the coast of Ireland in 1881, and weighed eighty-four and three-fourths pounds.

The salmon is found in Europe between the latitudes of 45° and 75°. In the United States, it is now rarely seen south of Cape Cod, although formerly the Hudson and numerous other rivers were salmon streams. Over-fishing, obstructions in the rivers, and pollution of the water by manufactories and by city sewage are agencies against which the salmon cannot cope.

Seven species of salmon (as distinguished from trout) are recognized, by Dr. Günther, in Europe and three in America. The land-locked forms, abundant in Norway, Sweden, and Maine, which cannot, or at least do not, descend to the sea, are regarded by him as distinct species. "The question," observes Dr. Günther, "whether any of the migratory species can be retained by artificial means in fresh water, and finally accommodate themselves to a permanent sojourn therein, must be negatived for the present."

On this point I am compelled to disagree from Dr. Günther. I have compared numerous specimens of the common land-locked salmon (*Salmo salar*, var. *sebago*) of the lakes of Maine and New Brunswick with land-locked salmon (*Salmo salar*, var. *hardini*) from the lakes of Sweden, and also with numerous migratory salmon both from America and Europe. I can have no hesitation in regarding all as specifically identical. The

differences are very trivial in kind, and not greater than would be expected on the hypothesis of recent adaptation to lake-life. We have, therefore, on our Atlantic coast but one species of salmon, *Salmo salar*. Dr. Francis Day, who has very thoroughly studied these fishes, takes, in his Memoir on the Fishes of Great Britain and Ireland, and in other papers, a similar view in regard to the European species. Omitting the species with permanent teeth on the shaft of the vomer (sub-genus *Salar*) he finds among the salmon proper but two species, *Salmo salar* and *Salmo trutta.*

The latter species, the sea-trout or salmon-trout of England, (Fig. 99) is similar to the salmon in many respects, but has rather smaller scales, there being 14 in an oblique series between the adipose fin and the lateral line. It is not so strong a fish as the salmon, nor does it reach as large a size. Although naturally anadromous, like the salmon, land-locked forms are not uncommon. These have been usually regarded as different species, while aberrant or intermediate individuals are usually regarded as hybrids.

The present writer has examined many thousands of American Salmonidæ, both of *Oncorhynchus* and *Salmo.* While many variations have come to his attention, and he has been compelled more than once to modify his views as to specific distinctions, he has never yet seen an individual which he had the slightest reason to regard as a 'hybrid.' It is evident that in America but few species of Salmonoids exist, and that these are subject to many variations. It is certainly illogical to conclude that every specimen which does not correspond to our closet-formed definition of its species must, therefore, be a hybrid with some other. There is no evidence worth mentioning, known to me, of extensive hybridization in a state of nature in any group of fishes. This matter is much in need of further investigation, for what is true of the species in one region, in this regard, may not be true of others. The species of trout, also, may perhaps hybridize, while *Salmo salar* and the *Oncorhynchi* do not.

Dr. Günther observes: "Johnson, a correspondent of Willughby, had already expressed his belief that the different Salmonoids interbreed; and this view has since been shared by many who have observed these fishes in nature. Hybrids between the sewin (*Salmo trutta* var. *cambricus*) and the river trout (*Salmo fario*) were numerous in the Rhymney and other rivers of South Wales, before Salmonoids were almost exterminated by the pollutions allowed to pass into those streams, and so variable in their characters, that the passage from one species to the other could be demonstrated in an almost unbroken series, which might induce some naturalists to regard both species as identical. Abundant evidence of a similar character has accumulated, showing the frequent occurrence of hybrids between *Salmo fario* and *S. trutta*. . . . In some rivers the conditions appear to be more favorable to hybridism than in others, in which hybrids are of comparatively rare occurrence. Hybrids between the salmon and other species are very scarce everywhere."

The black-spotted trout, forming the sub-genus *Salar*, differ from *Salmo salar* and *Salmo trutta* in the greater development of the vomerine teeth, which are persistent throughout life, in a long double series on the shaft of the vomer. About seven species are laboriously distinguished by Dr. Günther, in the waters of western Europe. Most of these are regarded by Dr. Day as varieties of *Salmo fario.* The latter species, the common river-trout or lake-trout of Europe, is found throughout northern and central Europe, wherever suitable waters occur. It is abundant, gamey, takes the hook readily, and is excellent as food. It is more hardy than the different

species of charr, although from an æsthetic point of view it must be regarded as inferior to all of the *Salvelini*. The largest river trout recorded by Dr. Day weighed twenty-one pounds. Such large individuals are usually found in lakes in the north, well stocked with smaller fishes on which the trout may feed. Farther south, where the surroundings are less favorable to trout-life, they become mature at a length of less than a foot, and a weight of a few ounces. These excessive variations in the size of individuals have received too little notice from students of Salmonidæ. Similar variations occur in all the non-migratory species of *Salmo* and of *Salvelinus*. Numerous river-trout have been recorded from northern Asia, but as yet nothing can be definitely stated as to the number of species actually existing.

In North America, only the region west of the Mississippi Valley and the valley of Mackenzie River, have species of black-spotted trout. If we are to follow the usage of the names salmon and trout, which prevails in England, we should say that it is only these western regions which have any trout at all. Of the number of species (about twenty in all), which have been indicated by authors, certainly not more than four can really be regarded as distinct species, and of these four, two are, as will be seen, still somewhat doubtful. The other names are either useless synonyms, or else they have been applied to local varieties which pass by degrees into the ordinary types.

Of the American species, the rainbow trout (*Salmo irideus*) most nearly approaches the European *Salmo fario*. It has the scales comparatively large, although rather smaller than in *Salmo fario*, the usual number in a longitudinal series being about 135. The mouth is smaller than in the other American trout; the maxillary, except in old males, rarely extending beyond the eye. The caudal fin is well forked, becoming in very old fishes more nearly truncate. The color, as in all the other species, is bluish, the sides silvery in the males with a red lateral band, and reddish and dusky blotches. The head, back, and upper fins, are sprinkled with round black spots, which are very variable in number. In specimens taken in the sea, this species, like most other trout in similar conditions, is bright silvery, and sometimes immaculate.

This species is especially characteristic of the waters of California. It abounds in every clear brook, from the Mexican line northward to Mount Shasta, and occasionally in coastwise streams to Alaska. No specimens have been anywhere obtained to the eastward of the Cascade range or of the Sierra Nevada.

It varies much in size, specimens from northern California often reaching a weight of six pounds, while in the Rio San Luis Rey, the southernmost locality from which I have obtained trout, they seldom exceed a length of six inches. Although not an anadromous species, the rainbow trout frequently moves about in the rivers, and it often enters the sea. Several attempts have been made to introduce it in eastern streams. It is apparently more hardy and less greedy than the American charr, or brook trout (*Salvelinus fontinalis*). On the other hand, it is distinctly inferior to the latter in beauty and in gaminess.

The steel-head (*Salmo gairdneri*) is a large trout, of fifteen to twenty pounds in weight, found very abundantly in the mouth of the Columbia and other rivers, in the spring, at the time of the early salmon run. These are evidently spent fishes, indicating a spawning time later (probably mid-winter) than that of the salmon, and their occurrence in the rivers at the salmon run is evidently due to a return toward the sea. Steel-heads are occasionally taken in the Sacramento, but in the Columbia they are abundant. They are rejected by the salmon fishermen, as their flesh is pale, and the bones are much more firmly ossified than in the species of *Oncorhynchus*. The

soft character of the bones in the latter group, as compared with those of the large trout, is one feature of their excellence as food.

Comparing the steel-heads with the rainbow trout, we find no differences, other than that the former is much larger in size, and has a larger mouth, and its caudal is truncate instead of forked. But the tail becomes more truncate, and the mouth larger with age in all species. If a rainbow trout were to reach the size of the steel-head, it ought to acquire characters similar to those of the latter species. Conversely, unless the rainbow trout are young steel-head, the young of the latter species is unknown. It is my belief that the steel-head is simply the large rainbow trout which has lived in the sea, and ascended the river to spawn. If this be true, *Salmo irideus* must be omitted from our lists, as identical with *Salmo gairdneri*.

The most widely distributed, and in almost all respects the most important, of the America black-spotted trout is the *Salmo purpuratus*, or, as we may call it, the red-throated trout. This species has much smaller scales than the rainbow trout or steel-head, the usual number in a longitudinal series being 150 to 170. Its mouth is proportionately larger, and there is usually a narrow band of small teeth on the hyoid bone at the base of the tongue. These teeth are always wanting in *Salmo irideus*, *gairdneri*, and *spilurus*. The color in *Salmo purpuratus* is, as in other species, excessively variable. In almost all specimens there is a deep-red blotch on the throat, between the branches of the lower jaw, and the membrane connecting them. This I have not found in other species, and as it seems to be constant in all varieties of *Salmo purpuratus*, at all ages, it will furnish a good distinctive character.

The red-throated trout is found in every suitable river and lake in the great basin of Utah, in the streams of Colorado, Wyoming, and Montana, on both sides of the Rocky Mountains. It is also found throughout Oregon, Washington, Idaho, British Columbia, and Alaska, probably no stream or lake suitable for salmonoid life being without it. In California the species seems to be comparatively rare, and its range has not been well made out. Large individuals apparently analogous to the steel-heads are sometimes found in the mouth of the Sacramento. In Washington Territory and Alaska this species often enters the sea. In Puget Sound, it is a common fish. These sea-run individuals are more silvery and less spotted than those found in the mountain streams and lakes. Numerous more or less tangible varieties of *Salmo purpuratus* occur, one of the most marked of which is the beautiful trout found in Lake Tahoe, the finest of all the mountain lakes of the Sierra Nevada.

The size of *Salmo purpuratus* is subject to much variation. Ordinarily four to six pounds is a large size, but in certain favored waters, as Lake Tahoe, and the fjord bays of the northwest, specimens of from 20 to 30 pounds are occasionally taken.

No attempt has been made to transport this, the finest known species of black-spotted trout, to eastern waters. The writer thinks it much better worthy of experiment than the rainbow trout. The great variety of the waters in which it occurs seems to promise a ready adaptation to other surroundings.

The Rio Grande trout, (*Salmo spilurus*), is a large and profusely spotted trout found in the head-waters of the Rio Grande, and in the mountain streams of the great basin of Utah. Its scales are still smaller than those of the red-throated trout, to which it bears much resemblance, and of which it is probably simply a local variety.

The genus *Hucho* has been framed for the Huchen or Rothfisch (*Hucho hucho*), of the Danube, a large salmon differing from the genus *Salmo* in having no teeth on the shaft of the vomer, and from the *Salvelini*, at least in form and coloration. The

real characters of the genus, which seems to be distinct from *Salvelinus*, have not yet been worked out. The Huchen is a long and slender, somewhat pike-like fish, with depressed snout and strong teeth. The color is silvery, sprinkled with small black dots. It reaches a size little inferior to that of the salmon, and it is said to be an excellent food-fish. Little is known of its habits. It has, however, the reputation of being unusually voracious for a salmon.

The genus *Salvelinus* comprise the finest of the Salmonidæ, from the point of view of the angler or the artist. In England, the species are known as charr, in contradistinction to the black-spotted species of *Salmo*, which are called trout. The former

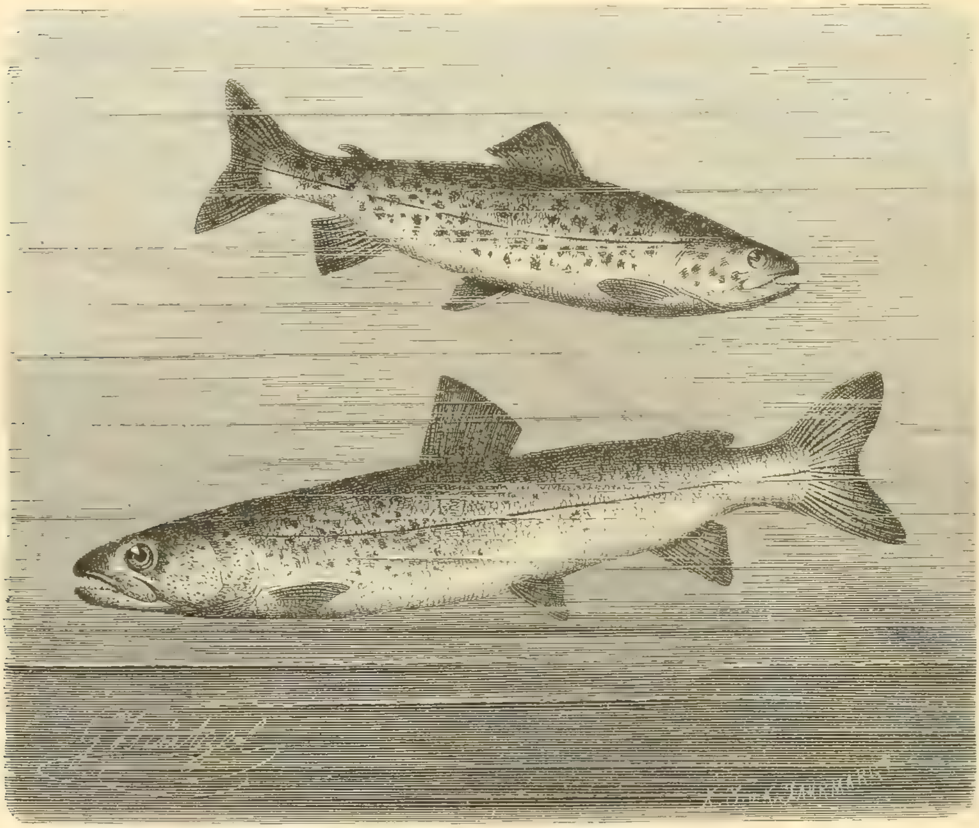


FIG. 100. — *Hucho hucho*, Huchen or Rothfisch, and *Salmo fario*, European lake trout (upper figure).

name has unfortunately been lost in America, where the name trout is given indiscriminately to both, and, still worse, to numerous other fishes (*Cynoscion*, *Micropterus*, *Hexagrammus*) wholly unlike the Salmonidæ. It is sometimes said that the "American brook-trout is no trout, nothing but a charr," almost as though charr were a word of reproach. Nothing higher, however, can be said of a salmonoid than that it is a charr.

The technical character of the genus *Salvelinus* lies in the form of its vomer. This is deeper than in *Salmo*, and when the flesh is removed, the bone is found to be somewhat boat-shaped above, and with the shaft depressed and out of the line of the chevron. Only the chevron is armed with teeth, and the shaft is covered by skin. In

one species (*S. namaycush*), the chevron sends a projection backward, which bears teeth, these teeth appearing, unless the flesh is removed, as if standing on the shaft of the bone.

In color, all the charrs differ from the salmon and trout, the body being covered with round spots which are paler than the ground color, and crimson or gray. The lower fins are usually edged with bright colors. The sexual differences are not great. The scales, in general, are smaller than in other Salmonidæ, and they are imbedded in the skin to such a degree as readily to escape notice.

> " One trout scale in the scales I 'd lay
> (If trout had scales) and 't will outweigh
> The wrong side of the balances." — LOWELL.

The charrs inhabit, in general, only the clearest and coldest of mountain streams and lakes. They are not migratory, or only to a limited extent. In northern regions they descend to the sea, where they grow much more rapidly and assume a nearly uniform silvery gray color. The different species are found in all suitable waters throughout the northern parts of both continents, except in the Rocky mountains and great basin, where only the black-spotted trout occur.

The number of species of charr is very uncertain, as, both in America and Europe, trivial variations and individual peculiarities have been raised to the rank of species. More types, however, seem to be represented in America than in Europe.

The only well-authenticated species in European waters is the red charr, Sälbling, or Ombre Chevalier (*Salvelinus alpinus*), Fig. 97. This species is found in cold, clear streams and lakes in Switzerland, Germany, and throughout Scandinavia and the British Islands. Compared with the American charr or brook trout, it is a slenderer fish, with smaller mouth, longer fins, and smaller red spots, which are confined to the sides of the body. It is a " gregarious and deep-swimming fish, shy of taking the bait, and feeding largely at night-time. It appears to require very pure and mostly deep water for its residence." It is less tenacious of life than the trout. It reaches a weight of from one to five pounds, probably rarely exceeding the latter size. The various charr of Siberia are too little known to be enumerated here.

Of the American charr, the one most resembling the European one is the Rangeley Lake trout (*Salvelinus oquassa*). The exquisite little fish is known in the United States only from the Rangeley chain of lakes in western Maine. Quite lately specimens of what appears to be the same species have been taken in arctic America, about Cumberland Gulf. Whether the species still inhabits any intervening waters is unknown. The Rangeley trout is much slenderer than the common brook-trout, with much smaller head and smaller mouth. In life, it is dark blue above, and the deep red spots are confined to the sides of the body. The species rarely exceeds the length of a foot. So far as is known, it keeps itself in the depths of the lake until its spawning season approaches, in October, when it ascends the streams to spawn.

Another beautiful little charr, allied to *S. oquassa*, is the Floeberg charr (*Salvelinus arcturus.*) This species has been brought from Victoria Lake and Floeberg Beach, in the extreme northern part of arctic America, the northernmost point whence any salmonoid has been obtained.

The American charr, or, as it is usually called, the brook-trout (*Salvelinus fontinalis*), although one of the most beautiful of fishes, is, perhaps the least graceful of all the genuine charrs.

It is technically distinguished by the somewhat heavy head and large mouth, the

maxillary bone reaching more or less beyond the eye. There are no teeth on the hyoid bone, traces at least of such teeth being found in nearly all the other species. Its color is somewhat different from that of the others, the red spots being large, and the back more or less mottled and barred with darker olive. The dorsal and caudal fins are likewise barred or mottled, while in the other species they are generally uniform in color.

The brook trout is found only in streams east of the valleys of the Mississippi and the Saskatchawan. It occurs in all suitable streams of the Alleghany region and the great lake system, from northern Georgia northward at least to Labrador and Hudson Bay, the northern limits of its range being as yet not well ascertained. It varies greatly in size, according to its surroundings, those found in lakes being larger than those resident in small brooks. Those found farthest south, in the headwaters of the Chattahoochee, Savannah, Catawba, and French Broad, rarely pass the dimensions of

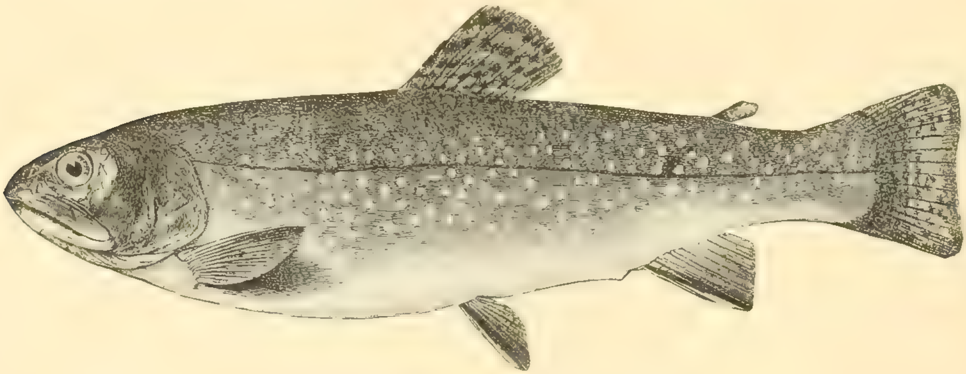


FIG. 101. — *Salvelinus fontinalis*, brook trout.

fingerlings. The largest specimens are recorded from the sea along the Canadian coast. These frequently reach a weight of ten pounds, and, from their marine and migratory habits, they may be regarded as forming a distinct variety, *Salvelinus fontinalis* var. *immaculatus*. The largest fresh-water specimens rarely exceed seven pounds in weight. Some unusually large brook trout have been taken in the Rangeley lakes, the largest known to me having a reputed weight of eleven pounds.

The brook trout is the favorite game-fish of American waters, pre-eminent in wariness, in beauty, and in delicacy of flesh. It inhabits all clear and cold waters within its range, the large lakes and the smallest ponds, the tiniest brooks, and the largest rivers, and, when it can do so without soiling its aristocratic gills on the way, it descends to the sea and grows large and fat on the animals of the ocean.

Although a bold biter, it is a wary fish, and it often requires much skill to capture it. It can be caught with artificial or natural flies, minnows, crickets, worms, grasshoppers, grubs, the spawn of other fishes, or even the eyes or cut pieces of other trout. It spawns in the fall, from September to late in November. It begins to reproduce at the age of two years, then having a length of about six inches. In spring-time, the trout delight in rapids and swiftly running water, and in the hot months of midsummer they resort to deep, cool, and shaded pools. Later, at the approach of the spawning season, they gather around the mouths of cool, gravelly brooks, whither they resort to make their beds. (*Hallock.*)

The trout are rapidly disappearing from our streams through the agency of the manufacturer and the summer boarder. In the words of an excellent angler, Myron W. Reed, — "This is the last generation of trout-fishers. The children will not be able to find any. Already there are well-trodden paths by every stream in Maine, in New York, and in Michigan. I know of but one river in North America by the side of which you will find no paper collar or other evidence of civilization. It is the Nameless River.

"Not that trout will cease to be. They will be hatched by machinery and raised in ponds, and fattened on chopped liver, and grow flabby and lose their spots. The trout of the restaurant will not cease to be. He is no more like the trout of the wild river than the fat and songless reed-bird is like the bobolink. Gross feeding and easy pond life enervates and depraves him.

"The trout that the children will know only by legend is the gold-sprinkled, living arrow of the white water; able to zig-zag up the cataract; able to loiter in the rapids; whose dainty meat is the glancing butterfly."

The brook trout adapts itself readily to cultivation in artificial ponds. It has been successfully transported to Europe, and is already abundant in certain streams in England and elsewhere.

The "Dolly Varden" trout (*Salvelinus malma*) is very similar to the brook trout, closely resembling it in size, form, color, and habits. It is found in the streams of northern California, Oregon, Washington, British Columbia, and Alaska, mostly to the westward of the Cascade Range. It often enters the sea, and specimens of eleven pounds weight have been obtained by the writer in Puget Sound.

The Dolly Varden trout is, in general, deeper in body, and less compressed than the eastern brook trout. The red spots are found on the back of the fish as well as on the sides, and the back and upper fins are without the marblings and blotches seen in *Salvelinus fontinalis*. In value as food, in beauty, and in gaminess, *Salvelinus malma* is very similar to its eastern cousin. The Greenland charr (*Salvelinus stagnalis*) seems to be distinguished chiefly by the great length of its fins. Little is known of its habits.

Allied to the true charrs, and now placed with them in the genus *Salvelinus*, is the great lake trout, otherwise known as Mackinaw trout, longe or togue (*Salvelinus namaycush*). Technically, this fish differs from the true charrs in having on its vomer a raised crest behind the chevron, and free from the shaft. This crest is armed with strong teeth. There are also strong, hooked teeth on the hyoid bone, and the teeth generally are proportionately stronger than most of the other species.

The great lake trout is grayish in color, light or dark, according to its surroundings, and the body is covered with round paler spots, which are gray instead of red. The dorsal and caudal fins are marked with darker reticulations, somewhat as in the brook trout. The great lake trout is found in all the larger lakes from New England and New York to Wisconsin, Montana, and Alaska. It reaches a much larger size than any other *Salvelinus*, specimens of from fifteen to twenty pounds weight being not uncommon, while it occasionally attains a weight of fifty to eighty pounds. As a food fish it ranks high, although it may be regarded as somewhat inferior to the brook trout or the white-fish.

Compared with other salmonoids, the great lake trout is a sluggish, heavy, and ravenous fish. They have been known to eat raw potato, liver, and corn-cobs, refuse thrown from passing steamers. According to Herbert, "A coarse, heavy, stiff rod, a

long and powerful oiled hempen or flaxen line, on a winch, with a heavy sinker; a cod-hook, baited with any kind of flesh, fish, or fowl, is the most successful, if not the most orthodox or scientific, mode of capturing him. His great size and immense strength alone gives him value as a fish of game; but, when hooked, he pulls strongly and fights hard, though he is a boring, deep fighter, and seldom, if ever, leaps out of the water, like the true salmon and brook trout."

In the depths of Lake Superior is a variety of the great lake trout known as the siscowet (*Salvelinus namaycush*, var. *siscowet*), remarkable for its extraordinary fatness of flesh. The cause of this difference lies, probably, in some peculiarity of food, as yet unascertained.

The small family of Percopsidæ may be defined, in brief, as having the form and general characters of a salmonoid, with the mouth and scales of a Percoid. The premaxillaries form the entire margin of the upper jaw, and the small teeth are found only in the jaws. The bones of the head are full of mucous cavities. The fins are formed essentially as in the Salmonidæ. The scales are strongly ctenoid, and the rather large eggs are excluded through an oviduct. The family is one of especial interest as exhibiting transitional characters, and it is thought to be allied to certain fossil Isospondylous forms.

But one species is now known. The trout perch (*Percopsis guttatus*) is a small, silvery fish, reaching a length of about six inches. It is found in the great lakes and their tributaries, and occasionally in the Mississippi valley. At Chicago it abounds about the wharves, where it is used as bait.

Sub-Order IV.—HAPLOMI.

The sub-order Haplomi is characterized, among the physostomous fishes, by the absence of the præcoracoid arch. In most other respects the group agrees technically with the Isospondyli. There is never an adipose dorsal, and the rayed dorsal is more or less posterior in position, often placed opposite to the anal. The head is depressed above, and usually more or less scaly. The species are nearly all quite small in size, and all inhabit fresh or brackish waters, some of them being found in nearly all parts of the earth, with the exception of the Australian and Polynesian regions, and the western parts of the United States. There are three families, all easily distinguished.

The Esocidæ, or pikes, have the body long and slender, and the mouth large, its bones armed with very strong, sharp teeth of different sizes, some of them being movable. The upper jaw is not protractile, and its margin, as in the Salmonidæ, is formed by the maxillary. The scales are small, the dorsal fin far back and opposite the anal, and the stomach is without pyloric cœca. There is but a single genus, with about five species. Four of these are North American, the other one being found in Europe, Asia, and North America.

All the pikes are greedy and voracious fishes, very destructive to other species which may happen to be their neighbors; "mere machines for the assimilation of other organisms." Thoreau describes the pike as "the swiftest, wariest, and most ravenous of fishes, which Josselyn calls the river wolf. It is a solemn, stately, ruminant fish, lurking under the shadow of a lily-pad at noon, with still, circumspect, voracious eye; motionless as a jewel set in water, or moving slowly along to take up its position; darting from time to time at such unlucky fish or frog or insect as comes within its range, and swallowing it at a gulp. Sometimes a striped snake, bound for greener meadows across the stream, ends its undulatory progress in the same receptacle."

As food-fishes, all the Esocidæ rank high. Their flesh is white, fine-grained, disposed in flakes, and of excellent flavor.

The finest of the Esocidæ, a species to be compared, as a grand game fish, with the salmon, is the muskallunge (*Esox nobilior*). Technically, this species may be known by the fact that its cheeks and opercles are both naked on the lower half. It may be known also by its great size, and by its color, — young and old being spotted with black on a golden-olive ground.

The muskallunge is found only in the great lake region, where it inhabits the deeper waters, except for a short time in the spring, when it enters the streams to spawn. It often reaches a length of six feet, and a weight of sixty to eighty pounds. It is necessarily somewhat rare, for no small locality would furnish food for more than one such giant. It is, says Hallock, "a long, slim, strong, and swift fish, in every way formed for the life it leads, that of a dauntless marauder."

The pike (*Esox lucius*) is smaller than the muskallunge, and is technically best distinguished by the fact that the opercles are naked below, while the cheeks are entirely

FIG. 102. — *Esox lucius*, pike.

scaly. The spots or bars in the pike are whitish or yellowish, and always paler than the olive-gray ground color. It is the most widely distributed of all fresh-water fishes, being found from the upper Mississippi valley, the great lakes, and New England, to Alaska, and throughout northern Asia and Europe. It reaches a weight of ten to twenty pounds or more, being a large strong fish in its way, inferior only to the muskallunge. In England, *Esox lucius* is known as the pike, while its young are called by the diminutive pickerel. In America, the name pickerel is usually given to the smaller species, and sometimes even to *Esox lucius* itself, it being rather a synonym for pike than its diminutive.

Of the small pike, or pickerel, we have three species in the eastern United States.

These are greenish in color, and banded or reticulated, rather than spotted, and, in all, the opercles as well as the cheeks are fully covered with scales. One of these (*Esox reticulatus*) is the common pickerel of the Eastern States, which reaches a respectable size, and is excellent as food. The others (*Esox americanus*, *Esox vermiculatus*) seldom exceed a foot in length, and have no economic importance.

Closely allied to the Esocidæ is the small family of the mud-minnows, or UMBRIDÆ, which technically differ from the pike, chiefly in the smaller mouth and weak dentition. The two known species reach but a small size, and their distribution is somewhat anomalous, indicating perhaps a former wider range.

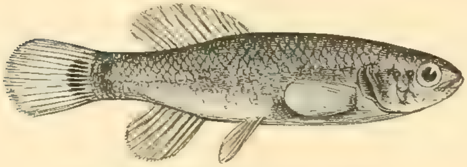


FIG. 103. — *Umbra limi*, mud minnow.

The species are sluggish, carnivorous fishes, living in weeds or mud at the bottoms of clear streams or ponds in rather cold regions. They are very tenacious of life, but do not live long in warm or turbid waters.

Of the known species, the Hundsfisch (*Umbra crameri*) is found in Austria. Its near relative, the mud minnow (*Umbra limi*) abounds in the streams and swamps of the northern states. It often lives for a long time imbedded in the mud of prairie sloughs and bog-holes, where it has sometimes been ploughed up alive.

The large family of CYPRINODONTIDÆ or killifishes, is distinguished among the Haplomi by the structure of its mouth. The short upper jaw is extremely protractile,

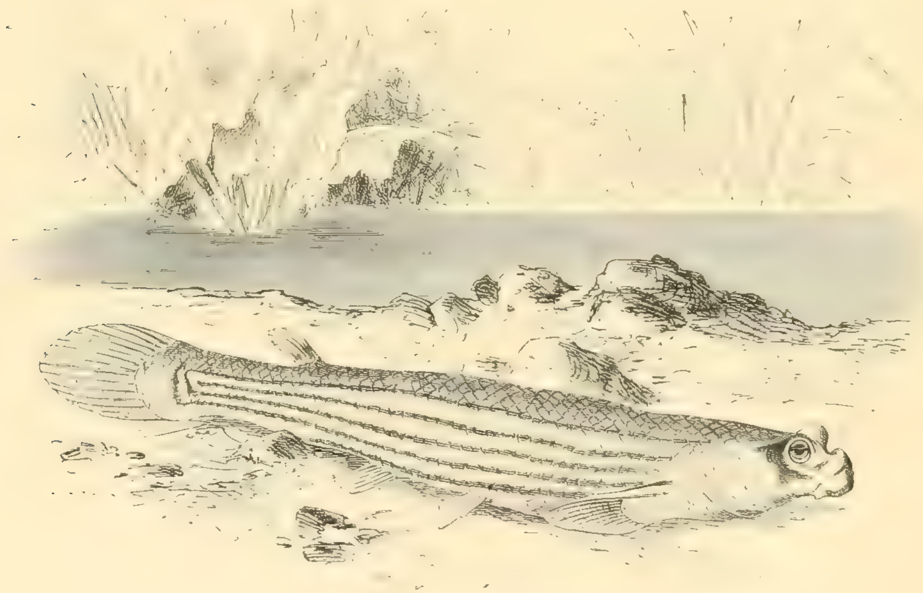


FIG. 104. — *Anableps tetrophthalmus.*

and its margin is formed by the premaxillaries alone. The teeth are small, and of various forms. The scales are large and cover the top and sides of the head. The stomach is without pyloric cœca, and the intestines are long or short according to the food of the fish.

About one hundred and forty species are now known, from the streams and brackish lagoons of the eastern United States, tropical and South America, Africa and Asia. Few are found in Europe, and few in the north Pacific region, and none much north of the latitude of Boston. The majority frequent brackish lagoons, lowland swamps, and mouths of rivers, but the strictly fresh-water species often abound in the clear fountain-heads of streams. Some African species live in hot springs.

The species are all of small size, some of them (*Heterandria*) being the smallest known vertebrates. The largest species (*Anableps*, *Fundulus*) seldom reach the length of a foot. In most species the sexes are dissimilar, and in several genera the anal fin of the male fish is modified into an intromittent organ, whereby the ova are fertilized before exclusion. Such species are ovo-viviparous, the young being developed in a sort of uterus, and being born at a comparatively advanced stage of growth. At birth, they closely resemble the adult fish. Most of the viviparous species feed upon mud; the others upon insects and small organisms. The majority are surface fishes, swimming about slowly, with their eyes partly out of the water. Others (*Cyprinodon*, *Fundulus*) are more active, and keep near the bottom, but always in very shallow waters. None of the species have any economic value. All are very tenacious of life.

Of the numerous genera, the following are some of the most noteworthy. The genus *Cyprinodon* comprises numerous chubby little fishes of the shores of America and southern Europe, provided with tricuspid incisor teeth. They are oviparous and carnivorous. Similar to these, but with a long dorsal fin and a general resemblance to young sun-fishes, is the genus *Jordanella* of the lakes and everglades of Florida. Most of the larger species belong to the genus *Fundulus*, which is widely distributed both in fresh waters and in salt. The largest North American species is *Fundulus majalis*; the most common, *Fundulus heteroclitus.*

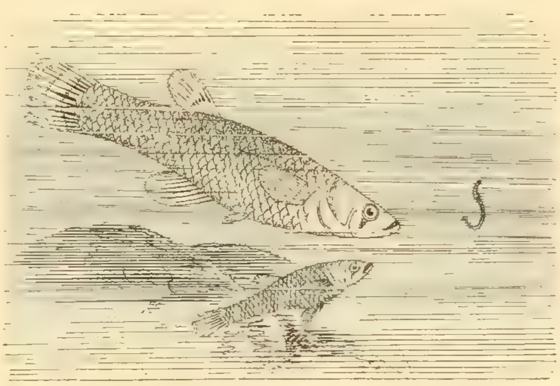


FIG. 105. — *Gambusia patruelis*, top minnow, male and female.

Of the genera with modified anal, and consequently ovo-viviparous, we may notice *Gambusia.* One species of the genus (*Gambusia patruelis*) abounds in all swamps and brooks of the lowlands of the south, and brings forth its brood in early spring. The males are smaller than the females and are much less numerous.

Allied to *Gambusia* are *Mollienesia*, with large, banner-like dorsal fin, *Pœcilia*, with smaller fins, *Xiphophorus*, with a sword-shaped lower lobe to the caudal, *Goodea*, with tricuspid teeth, and *Heterandria* with small teeth in a single row. *Heterandria formosa*, a pretty little fish of the southern lowlands, is said to be the smallest of fishes, rarely exceeding half an inch in length.

The most curious of the Cyprinodontidæ is the genus *Anableps* of the streams of tropical America. These are surface-swimming fishes, like *Gambusia* and *Zygonectes*. The prominent eye is divided by a horizontal partition into two parts, the upper adapted for vision in the air, the lower in the water. These fishes reach a length of more than a foot, being the largest of the Cyprinodontidæ.

The remarkable family of cave-fishes (AMBLYOPSIDÆ), is closely allied to the Cyprinodontidæ, differing among other things in the position of the vent, which is at the throat, instead of at the usual position behind the ventral fins. The mouth is larger than in the Cyprinodontidæ, and the upper jaw is scarcely protractile. The species are viviparous, the young *Amblyopsis* having at birth a length of one fourth of an inch. Other peculiarities of the members of the family are rather of the nature of adaptations for their peculiar mode of life.

The five species known are all small fishes, the largest not exceeding five inches in length. They inhabit the cave streams of Illinois, Indiana, Kentucky, Tennessee, and Alabama, and a single species is found in the ditches in the South Carolina rice-fields.

Two of the species (*Amblyopsis spelæus*, *Typhlichthys subterraneus*) inhabit only the depths of the subterranean rivers. In these species, the eyes are reduced to a

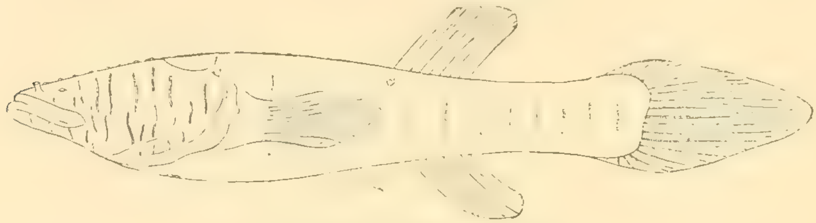


FIG. 106. — *Amblyopsis spelæus*, blind fish.

useless rudiment, hidden under the skin, the body is translucent and colorless, and the head and body are covered with numerous rows of sensitive papillæ, which form a very delicate organ of touch.

In the genus *Chologaster*, the eyes are well developed and the body colored as in ordinary fishes. In one species (*Chologaster papillifer*) tactile papillæ are developed, as in *Amblyopsis*. This species lives in cave springs of southern Illinois. In the other species there are no tactile papillæ. Of these species, one (*C. agassizi*) was taken from a well in Tennessee; the other (*C. cornutus*) is not a subterranean fish at all, being known, as above stated, from the rice ditches of South Carolina. Only the Mammoth Cave blind fish (*Amblyopsis spelæus*) is as yet common in collections, the others being comparatively rare. It is probable that other species will be found when the lowland swamps and cave streams of the south and west are more fully explored.

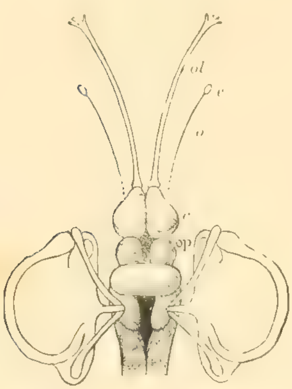


FIG. 107. — Nervous system of *Amblyopsis*: *c*, cerebrum; *e*, rudimentary eye; *o*, optic nerve; *ol*, olfactory nerve; *op*, optic lobes.

The origin of the blind-fishes is a source of interesting speculations. We can hardly resist the conclusion that the cave forms are descended from some species of the type of *Chologaster cornutus*, which inhabits the lowland streams with its allies, the viviparous Cyprinodonts. It is probable that the family was once more numerously represented than it is now, and extended itself over a wider range. The differences separating the Amblyopsidæ from the Cyprinodontidæ seem too radical for us to consider the latter as we now know them as the ancestors of the former, but the two groups probably have had, not far back, a common ancestry.

In regard to the peculiar position of the vent in the Amblyopsidæ, we may notice

that it occurs again in a very singular fish, *Aphredoderus sayanus*, which inhabits the same geographical range.

As to the habits of the blind-fish, I quote as follows from Professor Cope.

"If these *Amblyopses* be not alarmed, they come to the surface to feed, and swim in full sight like white aquatic ghosts. They are then easily taken by the hand or net if perfect silence be preserved, for they are unconscious of the presence of an enemy, except through the sense of hearing. This sense is, however, evidently very acute, for, at any noise, they turn suddenly downward and hide beneath stones, etc., at the bottom. They must take much of their food near the surface, as the life of the depths is apparently very sparse. This habit is rendered easy by the structure of the fish, for the mouth is directed upwards, and the head is very flat above, thus allowing the mouth to be at the surface."

Sub-Order V. — XENOMI.

This sub-order contains but a single family, the Dalliidæ. In all external respects the Xenomi resemble the Haplomi, but the structure of the pectoral elements of the skeleton distinguishes them sharply from all other soft-rayed fishes.

But one species of Dalliidæ is yet known. The black-fish of Alaska and Siberia (*Dallia pectoralis*) reaches a larger size than the mud-minnow, and is more pike-like in appearance. It furnishes a very important article of food to the natives of these northern regions, in which it is the only fresh-water fish, except the Salmonidæ.

D. S. Jordan.

Sub-Order VI. — SYNENTOGNATHI.

Intermediate between the typical Physostomous and Physoclistous fishes are certain forms which have been segregated into a sub-order under the name Synentognathi. The air-bladder is destitute of a communication with the intestinal canal, and the

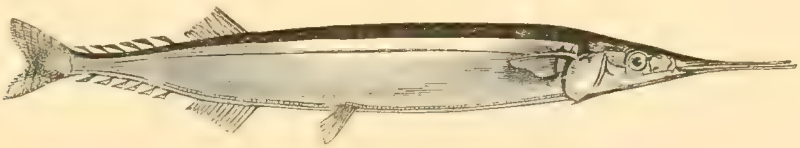


Fig. 108. — *Scomberesox saurus*, skipper, bill-fish.

fishes are to that extent physoclistous; but there are no spines to the dorsal, anal, or ventral fins, and consequently these forms more nearly resemble the great majority of physostomous fishes; the ventrals are also, as in the latter, abdominal in position. On the one hand the species in question are closely related to the Haplomi, and on the other to the Percesoces; and this resemblance, which is manifested in many structural characteristics, is extended by the likeness in external appearance. Two families have been distinguished among the representatives of this sub-order, the Exocœtidæ and the Belonidæ.

The flying-fishes are the representatives of a family somewhat numerous in species, comprising, in addition to the flying-fishes themselves, several types of special interest, whose extremes differ considerably from the flying-fishes, but which are, nevertheless, connected together by such gradations as to render it evident that the family is quite a natural one. The name Exocœtidæ should by rights be used for the family. Several well-marked groups or sub-families are embraced in it.

The Scomberesocines are distinguished by the compressed body, the extension of the jaws into more or less produced or elongated attenuated points, and a moderate development of the pectoral fins. A number of species are known, the most interesting of which are the *Scomberesox saurus* of Europe and America, and the *S. brevirostris* of the western American coast. The species seem to be to some extent migratory, approaching the coast in the commencement of summer, and departing before the end of autumn. They live in large schools, and swim mostly on the surface. They are capable of flight, but to a very limited extent, and, like the flying-fishes, avail themselves of their agility to escape their pursuers in the shape of porpoises or large species of their own class, such as the tunny, bonito, and related scombroid fishes. A most interesting spectacle, and that which well illustrates their great agility, is when they are followed by their pursuers. In the words of Mr. Couch, who speaks of the English form, "multitudes then mount to the surface, and crowd on each other as they press forward. When still more closely pursued, they spring to the height of several feet, leap over each other in singular confusion, and again sink beneath. Still further urged, they mount again and rush along the surface, by repeated starts, for more than one hundred feet, without once dipping beneath, or scarcely seeming to touch the water. At last the pursuer springs after them, usually across their course, and again they all disappear together. Amidst such multitudes — for more than twenty thousand have been judged to be out of the water together — some must fall a prey to the enemy; but, so many hunting in company, it must be long before the pursuers abandon. From inspection we could scarcely judge the fish to be capable of such flights, for the fins, though numerous, are small, and the pectoral far from large, though the angle of their articulation is well adapted to raise the fish, by the direction of their motions, to the surface."

The Scomberesocines are supposed to feed chiefly on soft pelagic animals. The statements as to their gaminess are somewhat contradictory, but the representative species, at least, is said rarely to take the bait, and when this has happened the boat has been under sail, the men fishing with a lash or slice of mackerel, made to imitate the living body. It is also rarely taken "since the drift fishermen began the practice of sinking their nets a fathom or two below the surface, a circumstance which marks the depth to which they swim; but before this it was usual to take them, sometimes to the amount of a few hundred, at almost every shoot of the pilchard nets."

Nearly related to the flying-fishes are species which have been distinguished as a sub-family, Hemiramphinæ, on account of the half bill, which is the result of the spear-like prolongation of the lower jaw, and the slight prolongation, or projection, of the upper. The form is straight and more or less elongated, and the most elongated species of the family belong to it; the dorsal, anal, and pectorals are generally moderately developed, but in some the pectorals are quite long, and the lower lobe of the caudal fin is also enlarged, thus, to some extent, resembling the Exocœtinæ. The species are quite numerous, and found in all tropical and sub-tropical seas. They associate together in large schools. Most are oviparous; but a few species, forming the genus *Zenarchopterus*, are viviparous, and have the anal fin much modified in relation to that habit. Representatives of two genera occur upon the American coast.

The genus *Hemiramphus* has species with a robust body, short pectorals, and moderate ventrals. One species is quite common along the Atlantic coast, and is found as far north as New Jersey; this is the *H. unifasciatus*. Another species, *H. brasiliensis*, has also been caught on the coast. A third species, *H. rosæ*, occurs on the Pacific

shores, and extends as far northward as southern California, where, however, it does not appear to be very common. The *Hemiramphus unifasciatus* is of considerable economical importance, being a rather savory fish, and is the object of pursuit, especially by the blue-fish.

The genus *Euleptorhamphus* is composed of species with a very slender body, long pectorals, and short ventrals. The species are pelagic, and inhabit the open seas; but one species, *E. longirostris*, has several times been caught along the Atlantic coast.

The flying-fishes proper, forming the sub-family of Exocœtines, are distinguished by the development of the pectorals, which are elongated and capable of considerable horizontal extension, so that the fish is buoyed up in the air, which it reaches by vigorous movements of its stout tail and caudal fin; the fin having a somewhat enlarged under lobe, considerably longer than the upper. By means of this disposition the upward impulse is accentuated, and the fish thereby enabled, and more effectively, to jump out of the water. The species of the family are pelagic, and representatives are found in almost all the tropical and warm seas. They associate together in schools of considerable size. The aerial flight is not strictly entitled to the name, for the pectoral fins are not used in active progression, but are simply employed as parachutes, to sustain the body in the air, and to diminish the tendency to obey the law of gravitation. The fins are, nevertheless, more or less vibrated, but it is rather by an opposition to the air than by the volition of the animal. Emergence from the water is effected almost solely by the well-developed caudal fin, and especially by the extension of its lower lobe. Contradictory statements have been made as to the rate and length of flight of flying-fishes. According to Professor Jordan, the flying-fish of southern California (*Exocœtus californiensis*) "flies for a distance of sometimes nearly a quarter of a mile, usually not rising more than three or four feet. Its motions in the water are extremely rapid, and its motive power is certainly the movement of its powerful tail in the water. On rising from the water, the movements of the tail are continued for some seconds until the whole body is out of the water. While the tail is in motion, the pectorals are in a state of very rapid vibration, and the ventrals are folded. When the action of the tail ceases, the pectorals and ventrals are spread, and, as far as we can see, held at rest. When the fish begins to fall, the tail touches the water, and the motion of the pectorals recommences, and it is enabled to resume its flight, which it finally finishes by falling into the water with a splash. When on the wing it resembles a large dragon-fly. The motion is very swift; at first it is in a straight line, but this becomes deflected to a curve, the pectoral on the inner side of the arc being bent downward. It is able, to some extent, to turn its course to shy off from a vessel. The motion seems to have no reference to the direction of the wind."

Ten species of flying-fishes have been observed off the North American coast; no less than nine have been taken along the eastern (*Exocœtus exiliens*, *E. rondeletii*, *E. vinciguerræ*, *E. volitans*, *E. heterurus*, *E. furcatus*, *E. gibbifrons*, *Halocypselus evolans*, and *Parexocœtus mesogaster*), but on the Pacific coast only one (the *Exocœtus californiensis*) has hitherto been secured. The Californian species is noteworthy as being one of the largest — if not actually the largest — of the family; it ordinarily attains a length of about sixteen or seventeen inches.

The genus *Fodiator*, very recently established, is distinguished for the sharp prolongation of the lower jaw, and is to some extent intermediate between the flying-fishes and the half-beaks, or Hemirhamphines.

Gar, or gar-fish, is a name generally applied by the English-speaking peoples to fishes having both jaws prolonged into elongated, narrowed, but stout bills. These elongated jaws are beset with numerous well-developed and sharp-pointed teeth. The dorsal and anal fins are far back, and opposite, and more or less developed, the dorsals sometimes being quite large and almost sail-like. Such fishes have been distinguished as a family under the name BELONIDÆ, and a number of anatomical characters confirm the separation from the Exocœtidæ, with which they have been generally confounded. It is noteworthy that the bones of all the species examined are greenish. The body is covered with cycloid scales, generally of a very small size, and the lateral line is decurrent, and runs low down on the sides. The species are quite voracious; and those of large size may be even dangerous to man himself. "They are very agile, and may occasionally be seen to leap out of the water. It seems that this propensity may be not without some inconvenience, or even danger, especially in the case of the large, stout-billed species. Mr. S. Archer 'was being pulled off from the shore to H. M. S. Himalaya in the harbor of Aden, when a fish jumped out of the water over the boat, and in doing so struck the hat of another officer, and knocked it into the water. When the hat was recovered' there was found 'in the hard felt a slit about four inches in length.' The fish was doubtless a gar. Professor Moseley, in comments upon this incident, asserts that 'it is the constant habit of large Belones,' — some of which attain a length of five feet, — 'when startled, to move along the surface of the water with astonishing rapidity.' Professor Moseley had 'seen them thus spring out of the water, when scared by a boat,' and had been told 'that in some of the Pacific islands these fish not uncommonly cause the death of the natives, who, when wading in the water, have their naked abdomens speared by the sharp snouts of the fish, with the result of causing peritonitis. The fish appear to bound blindly away from danger, and strike any object in their way haphazard.'"

The typical genus is *Belone*, and it is to this that the common gar-pike (*B. vulgaris*) belongs; but the American species are distinguished by the absence of gill-rakers, while *Belone* has them well developed, and also by the absence of teeth on the vomer or palatines. The tail, or caudal peduncle, is likewise generally more or less depressed and flattened outwards, ending sideways in callous ridges. In allusion to this last character, the generic name *Tylosurus* has been applied to them. Five species have been obtained along the eastern American coast, and one, *T. exilis*, on the Pacific side. The common species of the north Atlantic, *T. marinus*, although a true salt-water fish, often ascends far up into the fresh waters. A notable species, on account of the robustness and spike-like form of the jaws, is *T. gladius*, of the Florida coast and the neighboring Caribbean and gulf seas.

SUB-ORDER VII.— PERCESOCES.

We come now to a group of fishes which, on one hand, is evidently related to the three sub-orders just described, and, on the other, to the great host of Acanthopterygious or spiny-finned fishes which hereafter follow. The appropriate name, Percesoces, indicating this combination of the characters distinctive of the typical perch-like fishes and the pike-like form, was given by Prof. Cope. The group thus intermediate may be defined as teleost fishes with the ventrals sub-abdominal or abdominal, a spinous dorsal fin developed in addition to the soft, and the air-bladder destitute of connection with the intestinal canal. The group is now represented by but few

types, but these are all very characteristic and quite rich in species; the families have been named Sphyrænidæ, Atherinidæ, and Mugilidæ.

In all tropical and sub-tropical waters are found fishes of an elongated pike-like form, with the head compressed, conical, and pointed in front, the mouth well fissured and armed with strong teeth; two dorsal fins quite separated from each other, the first armed with five or six spines, and the hinder provided with one spine and nine or ten rays; the anal opposite the second dorsal, and like it in form and extent; the

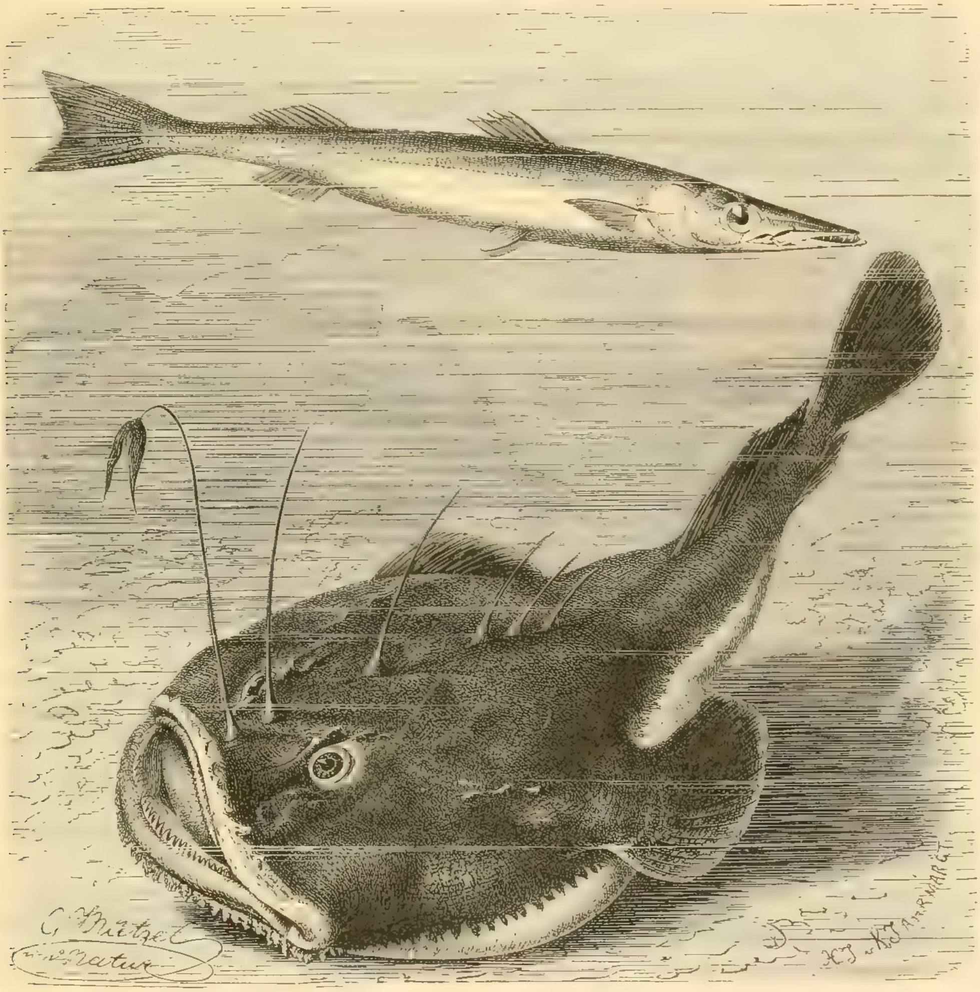


FIG. 109. — *Sphyræna spet*, barracuda (above), and *Lophius piscatorius*, fishing-frog, goose-fish (below).

ventrals not far behind the breast, and the vertebræ developed in normal number. The family so distinguished is named SPHYRÆNIDÆ. The fishes of this type, although more especially abundant in the equatorial and warmer seas, are represented by wanderers northward and southward. About twenty species are known, four of which visit the coast of the United States; of these, three wander more or less northward along the eastern coast, and one occurs on the western coast. The most general name along the American coast is barracuda, and this is applied to all the species both east and west.

The common and dreaded barracuda of the West Indies is the *Sphyræna picuda* of naturalists, and is common on the Florida coast; a couple of examples have been taken as far north as Wood's Holl, Massachusetts. Its special range is, however, the expanse of the Caribbean Sea and Gulf of Mexico; in these equatorial regions it is especially abundant. It is the largest, at least, of the American species of the family, and sometimes attains a length of eight feet and a weight of about forty pounds. Such large fishes are said to be as much dreaded as the great sharks, and their formidable armature renders them well capable of inflicting severe and even fatal wounds. It is, of course, a carnivorous fish, and destructive to the finny tribes generally. As a food fish it is under suspicion, and is indeed a species under the ban in the Cuban markets, as there have been repeated instances of severe sickness caused by eating its flesh. It seems, however, only, under special conditions that the flesh is poisonous, for generally it can be eaten with impunity, and is quite savory. *Sphyræna spet*, the common European species, is not rare on our coast.

The species representing the family on the western coast is *Sphyræna argentea*. It extends northward in summer to San Francisco, and great numbers are taken everywhere from Santa Cruz southward. It occurs in the greatest abundance at some distance from the coast, according to the depth of the water, three miles or more. It appears in late spring or summer, and the runs about the Santa Barbara Islands are in July or early in August; in about a month the adults usually disappear; the young, however, remain southward and are taken with the seine in winter. Anchovies form a large portion of its food. It is regarded as one of the best fishes of the west coast, and is especially esteemed when dried and salted, and in such state commands a higher price than the Alaska cod-fish.

A family rich in species, a few of which have some economical importance, is the ATHERINIDÆ. These have the body elongated, and generally the dorsal and abdominal outlines nearly parallel; but a few are most robust and subfusiform. The head is more or less conical and pointed, as seen from the sides. The teeth are small, and sometimes, though very rarely, entirely wanting. There are two dorsals, the first one having three to eight feeble spines, the second entirely separated from it, moderately well developed, and opposite the anal; the latter is generally the larger of the two. The ventral fins are small, and, although abdominal, not very far behind the breast, and composed of a small spine and five rays. The pectoral fins are inserted high up towards the shoulders. The vertebræ are quite numerous. Most of the species are more or less tinted with green on the back and sides, and have a broad, longitudinal, silvery band along the flanks. There are about ten genera, of which six are represented in the American waters. The typical genus, *Atherina*, has two species along the southern coast, *A. carolina* and *A. veliana*, but most of the east-coast species belong to the genus *Menidia*, and it is of this that the common silver-sides of the north (*M. bosci*) is a member. By far the largest and most valuable of the species is the *Atherinopsis californiensis* of the Californian coast. This attains the length of about eighteen inches, or perhaps even more, and is known in the San Francisco market as a 'smelt.' It is very savory, and quite highly esteemed for the table. A related species, *A. regius*, is one of the most highly esteemed fishes of the Chilian coast; and its popular name, pesce rey, or king-fish, bears testimony to the esteem in which it is held. One species, *Labidesthes sicculus*, is a fresh-water fish, living in lakes and sluggish streams from northern New York to Iowa and Tennessee.

The next family — that of the mullets, or MUGILIDÆ — has an almost universal distri-

bution in tropical and temperate waters, but the species ascend only a short distance up the Pacific coast of North America, and are wanting in the northern Californian waters and further northward. They are fishes that especially affect the brackish waters, and although they belong to the category of sea-fishes, a few, especially in tropical regions, are permanent residents of fresh water. Mullet is the name by which the species are known to almost all of the English-speaking races, but they must not be confounded with the celebrated mullet of the ancient Romans — the type of the family Mullidæ — for they belong to a different sub-order. A number of local modifications or prefixes to the name also occur: for example, the species along the American coast at Cape Hatteras are called jumping mullet and sand mullet, and in southeastern Florida, silver mullet and big-eyed mullet; specific forms or conditions are known as 'fat back' in Northampton county, Virginia, and in Florida; in Connecticut small ones are known as the bluefish-mummichog, a name due to an imagined similarity to the *Funduli* or true mummichogs. Seventy or eighty species represent the family in various parts of the world, and they are divided into eight or nine genera. The typical genus *Mugil* contains far more than all the others combined, and is the only one represented in the European and in American waters north of South Carolina. All the family have nearly the same external appearance; the form is elongated, with the back and ventral outline nearly parallel for the middle third of the length, and the head flattened and covered with large scales (as is also the entire body); the mouth is generally small and little extended backwards the teeth, when developed, as a rule, are very small. Two dorsal fins are present the first has always four spines, the first two of which diverge from the same base; the second fin is oblong, and some distance behind the first; the anal is like and opposite the second dorsal; the ventral fins arise a short distance behind the pectorals; and the caudal fin is stout, more or less emarginate, and has roundish lobes. The species associate together in large schools, and periodically appear in the warmer season on the coast which they inhabit; in the north, at least, they are supposed to retire to deeper water in the winter. Small mullet, however, are abundant all the year round along the southern United States coast, and isolated individuals are not infrequently taken.

Two species of *Mugil* occur on the Atlantic coast of the United States north of Florida, the *Mugil albula* (identified by Jordan and Gilbert with the *M. cephalus* of Europe) and the *Mugil curema* (better known as the *M. brasiliensis*); both range northward to Cape Cod, but the former is the most abundant in the north, and in the south is one of the most important, according to some, *the* most important food fish of the region. The *M. albula* has almost naked second dorsal and anal fins, and longitudinal stripes on the body; the *M. curema* has scaly second dorsal and anal fins, and there are no distinct lines of color along the sides. Other species advance on the Florida coast. Besides, a very small mullet of a peculiar generic type (*Querimana gyrans*) may be found from Florida to Charleston; it might easily be taken for the young of the large mullet, but is distinguished by the distinct teeth and the development of only two anal spines.

According to Goode, the large mullets begin to assemble along the Florida coast in schools in the height of summer, probably preparatory to spawning, and at this time the eggs commence to mature. In this season they swim at the surface, and are then pursued by enemies in the water and the air, and also fall an easy prey to the fishermen. They appear to prefer to swim against the wind, and school best with a northeast wind. They also run against the tide. In Florida the spawning season seems to

extend from the middle of November to the middle of January. "Some of the fishermen say that they go on the mud-flats and oyster beds at the mouth of the river to deposit their eggs. What becomes of them after this no one seems to know, but it is probable that they spread themselves over the whole surface of water-covered country in such a manner as not to be perceptible to the fisherman, who makes no effort at this time to secure the spent, lean fish. Many of them probably find their way to the lakes, and others remain wherever they find good feeding ground, gathering flesh and recruiting strength for the great strain of the next spawning season."

Professor Goode informs us that the fishermen recognize "three distinct periods of schooling and separate runs of mullet. To what extent these are founded on tradition, or upon the necessity of change in the size of the mesh of their nets, it is impossible to say. The 'June mullet' average about five to the pound; the 'fat mullet,' which are taken from August 20 to October 1, weigh about two pounds; these have, the fishermen say, a 'roe of fat' on each side as thick as a man's thumb. The 'roe mullet' weigh about two and a half pounds, and are caught in November and until Christmas. Between the seasons of 'fat mullet' and 'roe mullet,' there is an intermission of two or three weeks in the fishing." Professor Goode hazards the suggestion that "the 'fat mullet' of September are the breeding fish of November, with roes in an immature state, the ova not having become fully differentiated."

The largest fish appear rarely to exceed six pounds, but one was reported to Mr. Goode that weighed over seven pounds, and his informant had heard of one weighing fourteen pounds, and another which measured about twenty-nine inches in length.

Mullets, as a rule, feed on the bottom in still shoal water. They swim head downward, taking from time to time mouthfuls of earth which is partially culled over in the mouth. The microscopical particles of animal or vegetable matter are sifted out and retained, while the refuse is expelled.

In some of their attitudes, mullets are claimed, by Mr. Stearns, to resemble barnyard fowls feeding together; when a fish finds a spot rich in favored food, those near at once recognize the fact and flock around it, in the manner characteristic of poultry. They are said to eat little compared with other fishes of corresponding size, but this information we may regard as requiring confirmation. Their assimilative and digestive apparatus is curiously modified in relation to the food and the manner of taking it, and the pharyngeal armature exercises the function of a filter. The sand or mud taken in by the feeder is passed for some time between the pharyngeal bones, and the roughest and most indigestible portions are rejected and cast from the mouth. The stomach itself reminds one somewhat of a fowl's gizzard, and the entire intestinal canal is very much elongated, being as much as six or seven times as long as the fish itself, and makes a great number of circumvolutions.

There are certain fishes, living in the fresh waters of southern and eastern Asia, and especially in the East Indies, which are too interesting to be entirely passed over, and which it will be most convenient to notice here. They constitute a family named Ophiocephalidæ, and the species are quite commonly known in the East Indies as walking-fishes, and in China as living-fishes, or words signifying such in the vernacular of the countries referred to. By Professor Cope they have been referred to the Percesoces, but they exhibit fundamental differences from the other fishes of that division, and their true relations are therefore in doubt. The body is elongated, and in front subcylindrical, the scales moderate in size, and the head is somewhat snake-like, and covered above with large, shield-like scales (whence the name *Ophiocephalus*, or snake-

head); on the whole they have some resemblance to mullets. The dorsal fin is long, and without spines, and the ventrals are thoracic and have six rays, the first of which is simple but articulated towards its end; rarely are they wanting. A further noteworthy feature is the development of a cavity over the gill-chamber, lined with a thick membrane, and which is subservient to the respiratory function and co-ordinate with their peculiar habits. In fact, these fishes not only breathe air direct, but, if deprived of the opportunity to do so, die of asphyxia. They live some in rivers, selecting holes which are to be found along the banks, others in the reservoirs of water known in India as 'tanks,' and "delight in lying in the grassy edges, where the water is only sufficiently deep to cover them, so that they have no difficulty in respiring atmospheric air direct." They are monogamous, and prepare a sort of a nest for the future progeny, the male assuming the task of nest-building, and chiefly using therefor his tail, but "biting off the ends of the reeds that grow in the water." According to Dr. Day, they breed twice a year — about June and December. The male is the chief guardian of the nest, but the female may take up the duty if perchance her mate is lost and she left. In the dry season the fishes burrow in the mud, often to a depth of two feet, or even more. Occasionally they go out on the land, and, thus seen, have received the name of "walking-fish." The Chinese name, "langya," or "living-fish," is due, says Sir John Richardson, to the fact that they are "carried about in tubs, and sold in pieces cut from the fish when alive." Some reach a considerable size, *Ophiocephalus marulius*, according to Day, "attaining as much as four feet in length." Between twenty-five and thirty species of the family are known.

Sub-Order VIII. — Acanthopterygii.

We have next to deal with numerous fishes which agree in having a greater or less number of spines developed on the back, sometimes segregated in a distinct first dorsal, at others in the anterior portion of a single fin, in which case the posterior rays are generally branched. The anal has also usually two or three spines, — sometimes more, but rarely less than two. The ventral fins are inserted forwards, under or nearly under the pectoral, or sometimes considerably in advance of them, and the external rays are generally spinous. The forms so distinguished have usually been combined together in an order, or sub-order, called Acanthopterygii, or Acanthopteri; but the group is not a homogeneous one, and it is probable that when the various types shall have been dissected, and critically and comparatively studied, it will be found that several sub-orders will require to be recognized.

The first group which appears to demand our attention is composed of certain forms, some of which have a long geological history, and which have been generally combined in one family under the name Berycidæ. The diversities between the various representatives of the group are, however, considerable; and it seems to be rather a super-family, BERYCOIDEA, with several families. Only one is of sufficient general interest to detain us.

Under the names of squirrel-fish or Welshman, certain fishes, with the scales smooth on the surface but spinous on the margin, with the bones of the head more or less armed with ridges and spines, and whose color is generally of a reddish tinge, are popularly known to the English settlers in tropical countries, and especially in Florida, Bermuda, and the West Indies; these form the family Holocentridæ. The form is oblong, the head pointed, and the caudal is deeply emarginated, and has pointed lobes

with small spines along their upper and lower margins. The dorsal fin is deeply divided, or double, and the spinous portion much the longer. The ventral fins are provided each with a spine, and generally seven rays. The species are quite numerous, and found in all tropical seas; and one species, *Holocentrus ascencionis* or *pentacanthus*, occurs in the waters around Florida. It is an active fish, and its bright color and quick, darting motions render it "one of the most conspicuous denizens of the rock pools." The common name, squirrel-fish, is supposed to be due to sounds uttered by the fish, which are imagined to resemble the bark of a squirrel; and perhaps the red color is another reason for the application of the name.

Closely related to the Holocentridæ are families known as BERYCIDÆ, MONOCENTRIDÆ, and STEPHANOBERYCIDÆ. The representatives of these families are mostly deep-water fishes which rarely come under the observation of the ordinary traveler or collector.

Next, we may briefly consider some of a long series of forms which are typified by the common mackerel, and which have been kept together under the super-family name SCOMBROIDEA. The representatives of this combination were first collected together and segregated by Cuvier as a family designated Scomberoides, and were, according to the great French naturalist, a multitude of fishes with small scales, a smooth body, numerous cæcal appendages often compacted together, and whose tail and especially caudal fin are very powerful. The reasons given for the combination are certainly not very satisfactory; but that most (excluding several) of the types so approximated are really closely related appears to be clear, on comparison of the several constituents; and the proposition to intercalate them with other types, and scatter them in widely distinct groups, seems to be a retrograde course. The unctious, smooth body, unarmed scales, slender caudal peduncle, and powerful forked caudal fin, are reinforced by features of development and structure. The preoperculum, for instance, in very early youth, is armed with radiating spines, which are soon lost; the vertebræ and ribs have common characters, contrasting at least with those of the forms with which they have been sometimes associated; and development of numerous cæca, although perhaps of not much importance by itself, is a common feature, whose generality (not constancy) is somewhat significant. Further, the caudal peduncle, or base of the fin, is frequently strengthened by a longitudinal keel on the side, and oblique ones above and below, either alone or together. Nevertheless a good diagnosis of the group requires yet to be formulated. The group is still rather the result of tact in appreciation than of scientific analysis.

Many of the Scombroidea are of economical value; and one of the most important of food fishes has given name to the super-family. Many, if not most, of the species are pelagic, or inhabitants of the high seas; and among them we find those fishes which pre-eminently embody the idea of the fish form, — fusiform, with a powerful, forked tail-fin, and with a pointed head, all qualifying them in a superlative degree for rapid horizontal progression through the water.

Before reviewing the typical and specialized representatives of this great group, it will be convenient to consider a form which has been almost always closely associated with the Carangidæ, and which, in fact, does appear to be closely related, either as nearer the primitive or as a derivative form. Reference is had to the notorious bluefish, the type and only known representative of a peculiar family, the POMATOMIDÆ. The body is oblong, fusiform in outline, but considerably compressed, covered with scales arranged in oblique series, and with the lateral line running high up on the

sides; the head above is slightly curved, the jaws are armed with compressed and trenchant teeth, but of rather small size, and the palate is toothless; there are two dorsal fins, one sustained by about eight weak spines, the second, as well as the anal, long, and covered with scales; the tail is powerful, the fin deeply emarginated, and the ventrals are thoracic and normal, having a spine and five rays each.

The blue-fish (*Pomatomus saltatrix*), as it is generally called, rejoices in many other names according to locality or condition. Blue-fish is that by which it is known to by far the greatest number of people, and especially in the Middle and New England states, but in Rhode Island it is called horse-mackerel; it is the tailor of the Philadelphia, Baltimore, and Washington markets; in parts of Virginia and North Carolina it is known as green-fish; and south of Cape Hatteras the name changes to skipjack. The young in New England are often distinguished as snappers, blue snappers, and snapping mackerel, and in the vicinity of New York also as snapping mackerel, as well as white-fish. Some of these names are quite suggestive of the appearance or habits of the fish. Blue merging into greenish is the color; the teeth, though small, are sharp and lancet-like, and snip like a tailor's shears, and this peculiarity was also taken as the basis of a happy generic name (*Temnodon* or cutting-teeth), by Cuvier,

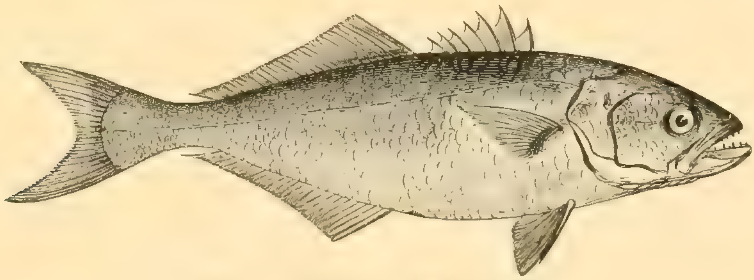


FIG. 110. — *Pomatomus saltatrix*, blue-fish.

but, unfortunately, that name must be given up for the much earlier one *Pomatomus*; snapping describes the movements by which it takes its prey, and skip-jack alludes both to its resemblance to the species of *Caranx*, and to the manner in which it often skips through the water. The young are whitish, and have not yet obtained the greenish-blue tints of maturity.

In size, individuals vary considerably. Those taken in the spring, as a rule, average much smaller than those obtained in the fall. About four pounds each may be considered as the medium size for the spring individuals about New York, while those occurring at the same time along the southern coast rarely exceed two or three pounds in weight. The largest summer specimens in fact, according to Professor Baird, are "those found farther to the eastward, where they are not unfrequently met with weighing from ten to fifteen pounds, although this latter weight is quite unusual." In the fall, however, the average size is much larger, and the schools that make their appearance in October on the northern coasts embrace many individuals of from ten to fifteen pounds, and it has been supposed by Professor Baird to be "not improbable that the difference between the first-mentioned average and the last represents the increase by their summer feeding." Much larger specimens than those indicated by these figures may, however, occasionally be found, and, in the last century, individuals appear to have been obtained weighing forty or fifty pounds in Vineyard Sound, and, according to one old observer, Zaccheus Macy, "thirty of them would fill a barrel."

Mr. Goode informs us that "a blue-fish weighing one pound measures about fourteen inches; two pounds, seventeen inches; three pounds, twenty-one inches; four pounds, twenty-four inches; five pounds, twenty-six inches, six pounds, twenty-six to twenty-seven inches, and eight pounds, twenty-nine inches."

The blue-fish is primarily a pelagic species, but is met with not so much in the high seas as within comparatively narrow distances of the coast; it is even prone to ascend great rivers, as high as fresh water. It is quite erratic in its movements, being absent in some years where it is abundant in others. Its distribution may, however, be said to be almost coincident with the warmer temperate seas, although there are many unexplained cases of absence. It extends along the entire eastern American coast, far into the northern, as well as into the southern hemisphere, and dwells in the Gulf of Mexico and the Caribbean Sea, in the Mediterranean, along the coast of South Africa, around Madagascar, in the Malay Archipelago, and in the Australian seas. It has, however, never been observed about Bermuda, and appears never to have ascended along the European coasts to the isothermal equivalents of the American seas where it abounds. No specimens have ever been recorded to have been obtained in Great Britain. In the words of Mr. Goode, "it is not yet known what limits of temperature are the most favorable to their welfare, but it would appear from the study of the dates of their appearance during a period of years in connection with the ocean temperature, that they prefer to avoid water which is much colder than 40 degrees," and "their favorite summer haunts are in the partially protected waters of the middle states, from May to October, with an average temperature of 60 to 75 degrees." As a rule, where one is found, many may be, for it is a gregarious fish and many associate together forming large schools.

The blue-fish, it is asserted, makes a regular migration along our coast, presenting themselves later and later in the spring the farther they are found to the north, and disappearing in the inverse order from the same regions in the autumn. They are first noticed on "the Carolina coast as early as March and April, immense schools of them, bound eastward, are seen off the coast of the Middle States, from the middle of May to the middle of June, and in October similar bodies, perhaps embracing fewer individuals, pass to the southward. It is possible, however, that in the autumn some schools move well out to sea, and are therefore less likely to be observed. They leave the northern coast about the middle of October, and about the middle of November appear in vast numbers off the coast of North Carolina," where a very extensive fishery is prosecuted chiefly for the northern markets.

Few fishes — perhaps we almost might say none — are more rapacious and sanguinary than the blue-fish. The United States Commissioner of Fisheries has especially deplored the ravages it commits upon other members of the finny class, and the contemplation of its bloody career has provoked him to eloquent denunciation. "There is," he says, "no parallel in point of destructiveness to the blue-fish among the marine species on our coast, whatever may be the case among some of the carnivorous fish of the South American waters. The blue-fish has been well likened to an animated chopping-machine, the business of which is to cut to pieces and otherwise destroy as many fish as possible in a given space of time. All writers are unanimous in regard to the destructiveness of the blue-fish. Going in large schools, in pursuit of fish not much inferior to themselves in size, they move along like a pack of hungry wolves, destroying everything before them. Their trail is marked by fragments of fish and by the stain of blood in the sea, as, where the fish is too large to be swallowed

entire, the hinder portion will be bitten off and the anterior part allowed to float away or sink. It is even maintained, with great earnestness, that such is the gluttony of the fish, that when the stomach becomes full, the contents are disgorged, and then again filled. It is certain that it kills many more fish than it requires for its own support."

Postulating that the blue-fish remains by the New England coast one hundred and twenty days, Prof. Baird has estimated that, if each blue-fish, averaging five pounds, devours or destroys even half its own weight of other fish per day (and he is "not sure that the estimate of some witnesses of twice this weight is not more nearly correct"), "we will have, during the same period, a daily loss of twenty-five hundred million pounds, equal to three hundred thousand millions for the season." Even this estimate takes account of "only three- or four-year-old fish, of at least three to five pounds in weight. We must, however, allow for those of smaller size, and a hundredfold or more in number, all engaged simultaneously in the butchery referred to."

Almost all fishes inhabiting the same waters may serve as prey to the blue-fish. "They appear," again to quote Prof. Baird, "to eat anything that swims, of suitable size, fish of all kinds, but perhaps more especially the menhaden, which they seem to follow along the coast, and which they attack with such ferocity as to drive them on the shore, where they are sometimes piled up in windrows to the depth of a foot or more." But they do not confine themselves to fishes; the squid appears likewise to be a favorite source of food, and worms that swim in the sea have also been found in large numbers in their stomachs.

The reproduction and early history of the blue-fish are still but partially known. It is asserted that in the Florida waters, in May and June, when the blue-fish enter the bays, mature females are found full of spawn. "With the larger fish the spawn is nearly ripe, and with the small and intermediate sizes is found in nearly all stages." According to Mr. Stearns, "the spawning season of the blue-fish in Florida includes several months, apparently May, June, July, and August." It is claimed that the fish spawns "in the bays, sounds, and bayous," and the young fry are found in July as well as parts of June and August as short as a half to three quarters of an inch in length. In November and December the smaller ones measure about three to five inches in length, and those of intermediate size from ten to fifteen inches. The time when they reach maturity is not known, but possibly it is three or four years. In the north, spawning fishes are scarcely ever seen, but young fish about five inches long, presumably those of the year, enter Vineyard Sound about the middle of August. By the beginning of September they are six to seven inches long, and on their appearance in the second year measure about twelve to fifteen inches in length, and thereafter increase in a still more rapid ratio. According to Prof. Baird, the fish which pass eastward from Vineyard Sound in the spring, weighing five to seven pounds, are represented, according to general impression, by the ten to fifteen pound fish of the autumn.

The blue-fish ranks as one of the most esteemed of the American food fishes, and is, it has been claimed, surpassed in popular esteem only by the Spanish mackerel and the pompano. It does not, however, keep very well, and there has been considerable caprice manifested in the esteem and demand for it. It is even still considered, or has been until lately, unfit for food in some ports of the south, and even in the markets of the capital of the country, and Prof. Goode remarks that in Washington

he has "frequently been stopped by fish-dealers who asked him to assure their customers that blue-fish were eatable. They are growing into favor everywhere, however, just as they did in Boston." In that city, according to Capt. Atwood, in 1865, but very few were sold, and when he first went to Boston with a lot, he obtained only two cents a pound, the second year he got two and a half cents, and the third three cents.

But the blue-fish is also one of the most esteemed of sea game-fishes and still more regarded by anglers for the sport which it furnishes than for the excellence of its flesh. It is a custom for many, during the summer, to take small vessels and sail along the coast trolling for these fishes. The armature for that purpose generally consists of a large hook with a wire leader and a long line let out by the hand alone. The hook is provided usually with a metal squid, whose brightness appears to be very attractive to the fish, for they rush in pursuit, snap at it, and are easily hooked. When one is hooked it should be immediately hauled in and if the line is kept taut the fish is apt to be thrown into the boat. Occasionally fish are also caught in certain places, from the shore, by throwing a hook as far as can be done, and immediately afterwards hauling it rapidly in again.

But excellent as the blue-fish is, both for esculent and game qualities, it is doubtful whether its goodness in those respects compensates for the havoc it commits among its co-inhabitants of the sea. Its ravages are sure to be felt in time, (we even now feel them) and it is a proof of the wonderful fecundity of nature that recovery can be and is so readily made after the murderous visitations of such hordes. A temporary cessation of its incursions on the American coasts may supervene as on former occasions and a "balance of power" for the natives of the sea be again established. Soon may it be!

Typical representatives of the Scombrioidea now demand our attention and the great importance of some of the species will call for more consideration than can be given to most other forms.

Carangidæ is the family name for the fishes generally known as cavally or crevalle, jack, pompano, scad, etc. These exhibit considerable difference in form, some being elongate fusiform, and others short, very much compressed, and high in the back. But most have an oblong body, which is moderately compressed, and the back and head more or less decurved. The scales are very smooth and entire on the borders; the lateral line arched in front and straight behind; there are two dorsal fins, the first usually provided with seven or eight spines, but sometimes the fin is atrophied; the second dorsal is long; the anal like the second dorsal, and generally armed with three spines, the first two of which, however, are ordinarily detached to form a separate finlet, although sometimes they are almost wanting, or not separated. The species of this division are very numerous in the tropical seas, and, being great swimmers, some of them have a very wide distribution. Several of the species are of special interest on account of their economical importance, or the characters which they exhibit.

The scad, *Trachurus saurus*, is a common species in Europe, and especially in the Mediterranean, and is likewise, although rarely, found along the southern Atlantic coast, as well as along the Pacific shores of America. It may be recognized at once by the row of high transverse plates which arm the entire lateral line from the shoulders to the caudal fins; the outline is symmetrically fusiform. It is too small to be of much economical value, although it is often used as a frying fish. It rarely reaches

the length of a foot; generally it is found in large schools swimming near the surface of the water, and its Dutch name is *marsbanker*. The original Dutch colonists of New York saw a resemblance in the mode of schooling and action of the menhaden and the *marsbanker* of their native country, and they applied to the American clupeid their name for the European fish, and thus was perpetuated in the United States a Dutch name for a fish very unlike that which it originally designated.

Closely related to the common scad is the big-eyed scad, also more generally known as the goggler, and goggle-eyed Jack — the *Trachurops crumenophthalmus* of naturalists. The very large prominent eyes are the most striking feature of the fish, and enable it to be readily identified. In appearance and habits it is much like the com-

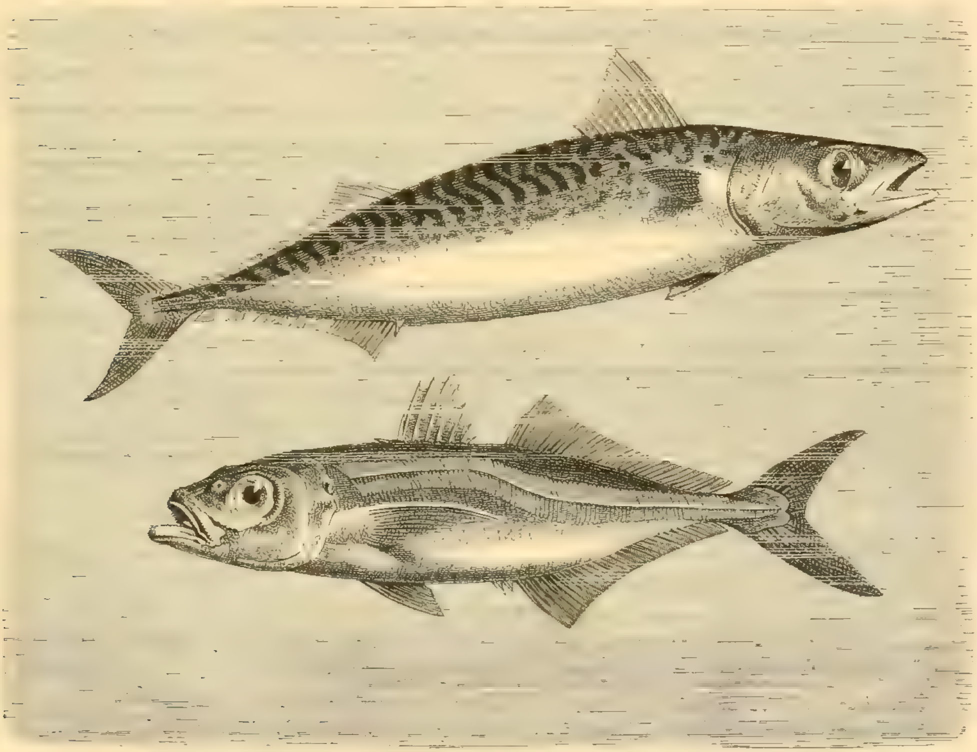


FIG. 111.— *Trachurus saurus* scad (below), and *Scomber scombrus*, mackerel (above).

mon scad of Europe, but the anterior portion of the lateral line is destitute of the vertical plates characteristic of the true scad. The species has a wide distribution in tropical seas and detachments occasionally ascend along the eastern coast of the United States, northward to Massachusetts.

The genus *Caranx* is a large one, embracing species whose lateral line is armed with elevated plates along its posterior portion, which have the front of the body oblong and the upper outline of the head decurved, a distinct first dorsal fin, and no dorsal or anal finlets. To this genus belong the common crevalle and horse crevalle of the eastern American coast.

The most common American species of *Caranx* is the *Caranx hippus*. The names by which it is mostly known are crevalle or cavalle, simply corruptions of the

Spanish name, caballa (a horse), and were borrowed by the American colonists from the prior Spanish settlers of America; horse crevalle is a tautological name, embodying the same idea in English and Spanish. It has a boldly rounded forehead, and twenty-one rays in the second dorsal. The average weight is estimated at about twelve pounds, although individuals may reach a weight of twenty pounds, or even more. Moderate sized or small fishes are best for the table; the larger ones being almost tasteless, and having dark flesh. It is a voracious fish, readily caught by trolling with a baited hook, and is even attracted by a rag attached to the hook; in some places, when the fish come close in to the shore, the favorite mode of killing them is shooting with a rifle.

Another species, closely related to the horse crevalle, is the *Caranx pisquetus*, but it is more slender, and has about twenty-four rays in the second dorsal fin. This species ranges farther to the north in abundance than any other of the genus. It is often called yellow mackerel (as about New York) or hard-tail.

Related to the preceding Carangidæ, are species which have the body extremely compressed and thin, and rising very high upward in the dorsal region, and which have the frontal outline as well as the back quite trenchant or sharp. The first dorsal fin is quite small and the spines very weak. Two well-determined species of this group wander to the American coast, and are noticed and prized by many persons on account of their unusual form.

The *Vomer setipinnis* is oblong, the forehead very declivous, and the anterior rays of the second and anal fins extend but little beyond the hinder ones; the posterior portion of the lateral line is covered with small plates. It is known as the blunt-nosed shiner, moon-fish, and horse-fish, and when young, sometimes as the dollar, fish. The young are quite different in shape from the old, and have a sub-rotund contour.

FIG. 112.—*Vomer setipinnis*, moon-fish, dollar-fish.

The *Selene gallus* is still more compressed and thinner than the *Vomer*, and the foremost rays of the hinder dorsal and anal become very long and give a falciform outline to the fins; the lateral line has no plates and is unarmed. Various popular names have been given, some of which are quite happy as descriptive epithets; such are, moon-fish, alluding to the silvery sheen of its body; look-down, recalling the high position of the eyes, and horsehead, or horse-fish, referring to the upward position of the eyes, and the consequently long extension in front, characteristic of both the equine animal and the *Selene*. As may be noticed, some of the same names have been applied to *Selene* as to *Vomer*.

The pompanos, or at least the one that is properly entitled to the name, also belong to the family Carangidæ, and constitute the genus *Trachynotus*. This genus may be distinguished by the more or less rhomboid form, the blunt nose, the reduction of the first dorsal fin to a few short spines unconnected by membrane, the elongated anterior rays of the second dorsal and anal fins, and the absence of any plates along the lateral line. The chief of the pompanos is the *Trachynotus carolinus*, although several other species are found along the coast. About Charleston it is known as the crevalle, and the true crevalle (*Caranx hippos*) is there designated as the horse-crevalle. The ordinary range of the pompano is northward to the coast of

South Carolina, and it occurs occasionally nearly as far north as Cape Cod, a number of specimens having been obtained at Woods' Holl; but it is chiefly young that have been seen north, the old being very sparingly represented. On the Gulf coast it is quite common, and is considered to be the choicest fish of the sea; a great commercial demand exists for it, which is fully supplied for only a few weeks in the year — in the spring and early summer. Along Florida, in the southern part, it is found throughout the year; but in the northern part it arrives on the coast in spring, and goes away from it in the fall. The movements of the fish are from the eastward, and they swim as near to the shore as the state of the water will permit; very seldom at the surface so as to ripple or break the water, although sometimes, while playing in shallow water, they will jump into the air. Its food seems to consist mainly of small shell-fish, which are supposed to be crushed between the pharyngeal bones. At Key West the pompano is caught in considerable numbers by hook and line.

The pompanos manifest great differences according to age. The old form has already been adverted to, especially in reference to the short spines unconnected by membrane, and the anterior rays of the dorsal and anal fins. In this condition, when very old, they are destitute of teeth in the jaws, and even on the pharyngeal bones. When they are very young, and of minute size, the spines of the first dorsal are well developed, and connected to form a true fin; the anterior rays of the second dorsal and anal are comparatively short; the teeth are developed in the jaws and pharyngeal bones, and the preoperculum is armed with several radiating spines. As the fish grows in size, first the preopercular spines are lost, then the membrane between the dorsal spines becomes reduced, and finally atrophied; meanwhile the dorsal and anal rays in front become elongated, and lastly the teeth are lost from the jaws and pharyngeal bones. The different stages of growth represented by these two extremes, and the intermediate ones, have given rise to several nominal genera.

The celebrated pilot-fish, *Naucrates ductor*, represents another group of Carangidæ, and is distinguished by its handsome and symmetrical fusiform shape, the development of about four spines unconnected by membrane, in place of a dorsal fin, and the existence of transverse black bars on a bluish ground. The species is almost cosmopolitan in distribution, but as a pelagic species, for it rarely comes close in shore. It does not often attain the length of much above a foot. The name of pilot-fish is derived from a supposed relation to sharks, with one of which it is generally found in company. According to Dr. Meyer, the pilot swims constantly in front of the shark, and he saw several instances in which the shark was led by its small companion. "When the sea-angel neared the ship, the pilot swam close to the snout, or near one of the breast fins of the animal. Sometimes he darted rapidly forwards or sidewards, as if looking for something, and constantly went back again to the shark." On another occasion, when a large hook, baited with a piece of bacon, was thrown overboard, the "shark was about twenty paces from the ship. With the quickness of lightning the pilot came up, smelt at the dainty, and instantly swam back again to the shark, swimming many times round his snout, and splashing, as if to give him exact information as to the bacon. The shark now began to put himself in motion, the pilot showing him the way, and in a moment he was fast upon the hook." On a later occasion, two pilots were observed in assiduous attention on a blue shark. "It seems probable that the pilot feeds on the shark's excrements, keeps his company for that purpose, and directs his operations solely from this selfish view."

Like the pompano, the pilot-fish exhibits considerable variations with age; when

extremely young, preopercular spines and a dorsal fin are developed; this stage has been described as a peculiar generic type, under the name *Nauclerus*; these spines, however, are soon lost. In extreme old age, the black bands are lost, and the fish is then nearly uniform in color.

Nearly related to the pilot-fish are certain forms which are known under the name of amber-fishes, rudder-fishes, and madregals. These belong to the genus *Seriola*. In form and coloration they essentially resemble the pilot-fish; but the spinous dorsal fin is always developed, and has generally seven spines. One species of the genus, the *Seriola dorsalis*, occurs along the southern Californian coast, and reaches a length of four or five feet, and a weight of from thirty to forty pounds. It is highly esteemed when fresh, but more especially when of moderate size, for large individuals are quite coarse and tough. It is also prized when salted and dried, and as a cured fish is considered to be inferior to none put up on the Pacific coast. It is chiefly caught by trolling. Several species occur on the Atlantic coast.

The name dolphin, formerly associated with the cetaceous mammals now better known as porpoises, has been transposed by our modern sailors to fishes related to the

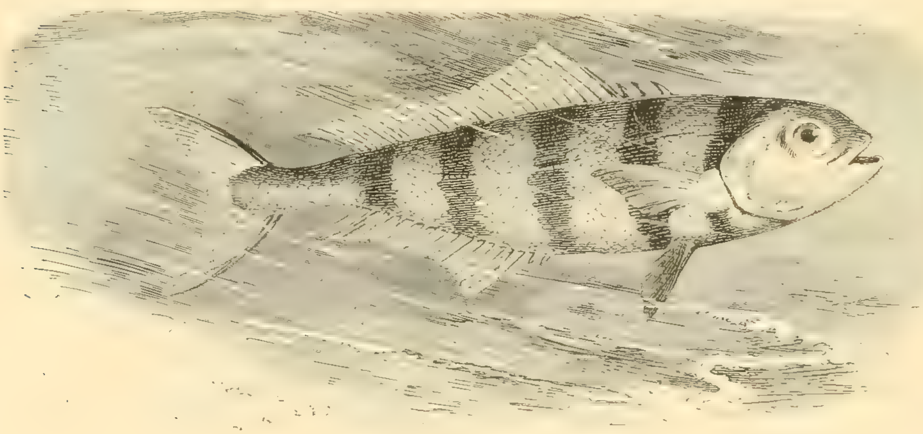


FIG. 113.—*Naucrates ductor*, pilot-fish.

mackerels, and the forms so known belong to a peculiar family named CORYPHÆNIDÆ. These have a rather peculiar form, being largest and highest at the head, and thence quite regularly diminishing to the slender tail. The back has a single fin extending from the nape behindwards, and only the foremost rays are spinous. The caudal fin is large and powerful, furcate, and running out into pointed lobes. The ventrals are thoracic, or somewhat anterior. The adult males, at least, have a very prominent forehead. The species exhibits brilliant, iridescent colors when first caught; and the changes in hue manifested by a dying fish have been celebrated by naturalists and poets. The species are quite large, reaching several feet in length, and are chiefly inhabitants of the open seas. They are often caught by the sailors in mid-ocean, and are generally excellent as food; their flesh is, however, liable to become poisonous under certain circumstances, and, according to Mr. Goode, "It is an almost universal custom before eating them to test the flesh by putting a piece of silver into the vessel in which they have been cooked, it being a common belief that, if the fish is poisonous, the silver will turn dark." The number of the species is uncertain; but

two, the *Coryphæna equisetis* and *Coryphæna hippurus*, occur occasionally along the eastern coasts of the United States.

Certain fishes forming the family STROMATEIDÆ have been generally placed next to the Coryphænidæ and the Carangidæ, although in fact they are not very closely related. The species of Stromateids vary in form, but the typical ones are longitudinally oval or pyriform in shape; they have a single long dorsal fin, with a few spines in front. The ventrals are generally under the bases of the pectoral, but in the principal forms they become more or less atrophied, or even lost entirely, in the adults. The chief character is the development of the rakers on the last branchial arch; these become more or less sac-like in appearance, and extend backwards into the œsophagus.

One of the principal members of the family is the species known in Massachusetts and New York as the butter-fish, in New Jersey as the harvest-fish, and in Maine as the dollar-fish. Its scientific name is *Stromateus* (or *Poronotus*) *triacanthus*. The name butter-fish is given in allusion to the smooth surface reminding one of the feel of butter; harvest-fish alludes to the time of its approach to the coast; and dollar-fish has reference to the roundish form and silvery hue. It is moderately esteemed as a food fish, and resembles mackerel in taste, but is less oily.

Along the Californian coast, a species related to the butter-fish of the east is found, and has been named *Stromateus simillimus*. In the San Francisco market it is known as the pompano, although it belongs to a different family from the true pompano of the east coast. It is very highly esteemed.

Another of the Stromateidæ worthy of mention is a species known as rudder-fish, log-fish, and barrel-fish; the scientific name is *Lirus perciformis*. This species is more oblong than the ones just described, and is of a blackish color. The preoperculum is radiatedly festooned around the margin, and the spines of the dorsal fins are well marked and set off, indeed, as a distinct portion of the fin. In the words of Mr. Goode, "the habits are peculiar in the extreme. They are most always found in the vicinity of floating barrels and spars, and sometimes inside of the barrels. Hence the fishermen call them barrel-fish, though the most usual name is rudder-fish. The last name has been evidently given by the sailors, because they are often found swimming about the sterns of the becalmed vessels. The fish attains a length of ten or twelve inches, and its flesh is quite savory."

Passing by other fishes of little or no economical importance, we reach the family of the SCOMBRIDÆ, or mackerels. The shape of all the species is fusiform, or more or less elongated; there is an independent spinous dorsal fin which is generally well developed and about as long as the second; but sometimes, as in the common mackerels, it is short; there is then a long interspace between it and the second fin; the last rays of the latter are almost always separated and developed as so many finlets. The anal fin answers to the second dorsal, and has also its last rays detached as finlets in the same way as the opposite fin. The upper jaw is connected with the main part of the head above by a continuous skin, and the maxillary bones fit in neatly on the sides, as if the skin and flesh had been cut out especially for their reception. The vertebræ are more numerous than in any of the preceding forms.

The true mackerels, constituting the genus *Scomber*, have the first dorsal short, distended by only nine to twelve spines, and very remote from the second; there are five finlets above and below; the vomer and palatines have small teeth, and the corselet is feebly developed or wanting. Three representatives of this genus are found in the northern Atlantic, and occur more or less frequently on the coasts of America.

The common mackerel of commerce, *Scomber scombrus*, is destitute of an air-bladder, and the upper surface of the head is almost uniformly dark and destitute of any transparent area; the scales are all minute, and no corselet is developed; and the first dorsal has normally twelve spines; the color above is a lustrous dark blue, traversed by about thirty-five undulating blackish bands or streaks, and below it is silvery; the pectorals are dark at the base. The great importance of this fish justifies a more detailed consideration than we have been able to give to other species, and for our information we will be largely indebted to recent reports by Goode, Collins, and Earle, from which we will take freely, with as little change of language as is necessary.

Mackerel, when well grown, are about seventeen or eighteen inches long, although sometimes they attain a larger size, perhaps nineteen or nineteen and a half inches long, or, very rarely, even somewhat more. The size varies however. A 'number one' mackerel, according to the Massachusetts inspection laws, measures thirteen inches from the tip of the snout to the end of the caudal fin. "The average length from year to year, for the whole coast, is probably not far from twelve inches," with a weight of twelve to sixteen ounces.

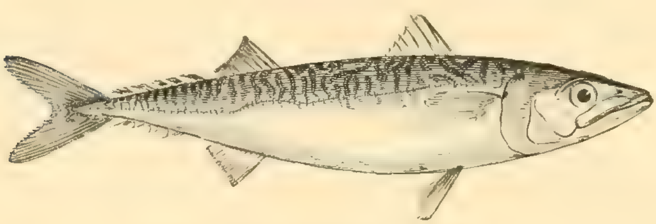


FIG. 114. — *Scomber scombrus*, mackerel.

In the American seas, the range of the mackerel extends from the neighborhood of Cape Hatteras, northward to Labrador and Newfoundland. In the early spring, as well as in the late summer and fall months, they may be found in the latitude of North Carolina, while in the summer months they abound off the coasts of the middle states and New England, and especially in the Gulf of St. Lawrence. They may be also found on the coast of Labrador, though there is no evidence that they ordinarily frequent the waters north of the Strait of Belle Isle, and it has been asserted that they visit northern Labrador only in seasons remarkable for the prevalence of westerly winds, and that in others they do not go so far northward. They neither visit Hudson Bay nor the coast of Greenland. On the eastern side of the Atlantic the species inhabits the entire length of the Norwegian coast, from the North Cape to Christiania Fjord, and it also occurs on the south coast of Sweden, in the Baltic, the German Ocean, and the English Channel, as well as almost everywhere round the British Islands, and southward to the Mediterranean, where it abounds, especially in the Adriatic Gulf. In short, the mackerel must be considered as a fish not addicted to wide wanderings in the ocean and with a normal range, limited in the western Atlantic between latitudes 35° and 56°, and in the eastern Atlantic between 36° and 71°. The species is, however, quite erratic in its appearance along the coast, and its movements appear to be determined by both temperature and food; primarily by temperature, and secondarily by the animals constituting its food, but, inasmuch as the distribution of the latter is determined chiefly by temperature, the factor is really mainly thermometric.

The migrations of the mackerel, according to Mr. Goode, are believed to be carried on in connection with another kind of migration, which he calls "bathic migration," and which consists in "a movement, at the approach of cold weather, into the

deeper waters of the ocean." Schools appear in the spring, and remain till fall, and "their presence is nearly synchronous with the time when the water temperatures of the harbor have reached a weekly average of 45 degrees." The "harbor temperatures are several degrees — it is not known exactly how many — higher than those of the open ocean at the same latitude." Mackerel "remain active and contented in a temperature of 40 degrees, or even less," and there are well-recorded instances where fishes have been taken "not only on the New England coast, but also in the Gulf of St. Lawrence, in mid-winter."

The principal food of the mackerel consists of such small crustaceans as abound everywhere in the sea, and the movements of the fish are determined to a large degree by theirs. "They also feed upon the spawn of other fishes, and upon the spawn of lobsters," and even prey greedily upon the young of other kinds of fishes, as well as upon pteropods, and jelly-fishes; indeed the Gaspé fishermen call jelly-fishes "mackerel bait." In short, they are — as the greed with which they feed upon the minced menhaden bait evinces — not at all dainty in their diet, and will swallow without hesitation almost any kind of floating organic matter. Cannibalism has also been charged against them, and young mackerel three or four inches long have been repeatedly found in the stomachs of full-grown individuals, but this, it has been observed, is generally noticeable only in the fall, and the young fish are probably those which have been hatched in the spring. The nature of the food is of some consequence to the fishermen. Among the crustaceans are certain species which are known to the fishermen as 'red-seed' and 'cayenne.' The so-called red-seed exercises a deleterious effect on the flesh of the fish, and the fishermen have great trouble in keeping fishes, which have indulged in such food, successfully, and dressing them properly, for their bellies soften at once. It is said by Dr. Robert Brown to be of "special importance to notice that very many, if not all, of these free-swimming creatures in the sea, from invisible microscopic forms to the largest shrimp, sink to different zones of water, or rise to the surface, with the variations in temperature and changes in the direction and force of the wind. In fine weather, when the food is at the surface, the mackerel, the herring, and other surface-feeders, with eager, staring eyes, and mouth distended to entrap the floating prey, swim open-mouthed against the wind. Mackerel, when feeding in large schools, remind one of a swiftly moving ripple on the water."

The reproductive process of the mackerel is of interest. It has been ascertained, as a result of reliable observation among the fishermen of our coast and the coasts of the British Provinces, that spawning takes place in rather deep water all along the shore from the eastern end of Long Island to Eastport, Maine, and along the coast of Nova Scotia. The spawning season occurs in May in southern New England, in May and June in Massachusetts Bay, and in June in the Gulf of St. Lawrence, and on the Bradley Banks and along the Magdalens early in the month, and, according to Hind, on the north-east coast of Newfoundland toward the end of the month. "The ova are shed in mid-water, and, after fecundation by the spermatozoa from the milt of the male, are carried to the surface of the ocean, where they are soon hatched. The growth of the new-born young fish is rapid, and in about seven weeks, it is said, the young fish are some four or five inches long. In the middle or latter part of the fall they are six to seven inches long, and are then sometimes called 'spikes;' the next year, when about a year old, they are known as 'blinks;' the following year, when two years old, they are 'tinkers.' A year after, being then three years old, they

return coastward as the 'second size.' It is probable that the fish reaches its full maturity in four years."

No notice of the mackerel — prime in importance as it is among economical fishes — would be justifiable without some reference to its economical history. Volumes have been written on this subject, but the present account must be condensed within the briefest limits, and be confined chiefly to the American fisheries. In olden times mackerel were fished for wherever they could be conveniently found, and chiefly with hook and line, but it has for a long time been the subject of a highly specialized fishery, employing a large number of vessels and men. The American fishing grounds at present extend from off Cape Hatteras northward to the ordinary range of the species. In the spring, the raid against the fishes commences between the capes of the Chesapeake and the south shoal of Nantucket, and is prosecuted chiefly by the seiners. The fishes are first seen from twenty to fifty miles from land, and thence gradually advance northwards, and toward the shore, and near the New Jersey coast and Long Island they have approached to within one or two miles of the land. "During the summer and fall months, the principal seining ground for mackerel is in the Gulf of Maine, from the Bay of Fundy to Cape Cod; the immediate vicinity of Mount Desert Rock, Matinicus, Monhegan Island, Cape Elizabeth, Boon Island, and Massachusetts Bay being the favorite localities." The principal ones frequented by the mackerel hookers, or those who confine themselves to hook and line, are the Gulf of Saint Lawrence, the Gulf of Maine, George's Bank, the south coast of New England, the coast of the middle states from Montauk Point to Delaware, and the eastern coast of Nova Scotia. The apparatus and capital engaged in this fishery is for the most part contributed by the states of Massachusetts and Maine, the quotas furnished by others being comparatively insignificant. By the census of 1880 it appears that 468 vessels, with a tonnage of 23,551.64 tons, and of the value of $1,027,-910, were employed in the American fisheries. The number of men engaged was 5,043, and the value of the gear and outfit was $1,084,450. Of this considerably more than half in tonnage, men, and capital invested was engaged exclusively in the mackerel fishery; but the rest were also used in other fisheries. Of this outfit, Massachusetts contributed a quota of 277 vessels of 16,674 tons, manned by 3,492 men, and Maine supplied 176 vessels of 6,122 tons, manned by 1,402 persons, while from New Hampshire 13 vessels set sail, and from Connecticut only 2. The value of the catch obtained by this fleet was $2,606,534, representing 111,399,855 pounds of round mackerel taken, of which 103,142,400 pounds were used for pickling, 4,957,455 pounds for canning, 1,100,000 pounds for fresh fish, 1,100,000 pounds for bait, and 500,000 pounds for fertilizers.

The vessels used in the fishery have been greatly modified, especially within the last thirty or forty years. Before the middle of the present century they were almost exclusively "square-stern schooners of from 25 to 80 or 90 tons," and "pinkies of from 20 to 60 tons;" most of them carried a flying jib. About or shortly before the commencement of the present half of the century, however, vessels better adapted, both for speed and the accommodation and care of the fish, were introduced, and were at first known as 'sharp-shooters.' "As early as 1855 the character of the fleet had become very much modified, there being a large percentage of modern-built vessels, and the pinkies and square-stern schooners were retained only by conservatives and by the smaller ports, especially those on the coast of Maine." "Even as early as 1870, the old square-stern

vessels and pinkies had entirely disappeared from the fleet, most of them long before that date."

The accessories to the vessel are seine-boats with their fittings and the seines. Two kinds of seines are used, (1) a large one only employed in connection with the largest seine boats, and (2) a small one. The large seine varies from 190 to 225 fathoms in length by 20 to 25 fathoms in depth, when it is hung, being deeper in the centre of the bank than at the extreme wings. The cork line has "two or three sizes of corks, the largest being placed over the baiting piece, the smallest generally at the end of the wings;" the lead line is "as in the ordinary seine, and is weighted with sinkers about two ounces in weight, which are attached to it at intervals varying from a few inches to several feet." When not in use, "the seine is stowed on a grating forward of the house and behind the hatch. The small seine differs from the large one in having a length of only 150 to 175 fathoms and a depth of 10 to 12; it is used "in shallow water, and those vessels which have gone to the Gulf of St. Lawrence for the purpose of catching mackerel by this method generally carried them." Many of the large schooners carry both kinds of seines, "whether they have two seine boats or not, since the deep seine cannot be used on rocky bottoms in shallow water."

The mackerel-hookers employ the so-called mackerel jig, mackerel fly-hook, mackerel gaff, and mackerel bob or bobber, and carry the necessary bait to attract the fish, and furnish the apparatus. A favorite way of baiting mackerel hooks is to take several thin strips from the belly or lower side of a mackerel, and cut them into sections about a half an inch square. "A large number of these pieces are put on the hook, completely filling the bend, after which the baits are scraped with the back of a knife, in such a manner as to remove everything but the tough white skin which, when distended in the water, forms a soft pulpy mass about the size of one's forefinger; but this can be contracted into a very small space, and thus afford the eager fish ample opportunity to secure a good hold of the hook while seeking the tempting, but yielding morsel upon it. A bait of this kind will last more than an hour without being renewed, even when mackerel are biting sharply."

The seiners, as well as hookers, carry bait, and the favorite one is "slivered and salted menhaden, of which each vessel usually carries five to ten barrels. Many, if not all of the vessels, however, at the present time, depend entirely upon small mackerel, which they catch and salt. The bait-mill, bait-boxes, and bait-throwers are similar to those used in the mackerel fishery, and are used in the same manner." This bait is chiefly employed in tolling the fish to the surface and, incidentally, catching them with jigs when they are not schooling. "Sometimes they toll the fish alongside and spread the seine around the vessel, and as she drifts over the cork rope and away to leeward the net is pursed up and the fish captured. It is often the case, too, where mackerel are moving rapidly, for the men in the dory to throw bait ahead of the school, and while the fish are thus induced to stop, the seine-boat circles around them, the net is thrown, and while yet engaged in feeding, the fish are enclosed in the big purse." One indispensable item of the furniture of a mackerel vessel remains to be mentioned, that is, the barrels to receive the fish when caught.

Doubtless much of the attraction to the men engaged in the mackerel fishery is the excitement and sport experienced in their encounters with the fish. In the words of Messrs. Goode and Collins, "the excitement among the crew, when the mackerel are biting fast, can hardly be described. When the fishing begins, the drumming of the mackerel in the empty barrels is inexpressibly cheering to the fishermen, especially if

they have been unsuccessfully hunting for fish on previous days, and adds to their excitement. This sound ceases as the barrels begin to fill up, the resonance of the wood being deadened by the accumulation of fish; it is, however, from time to time renewed, as empty barrels are substituted for those which have been filled. Every man is striving to the top of his bent to catch as many mackerel as possible while the 'spurt' continues, and, if possible, to catch a larger share than any of his comrades. The emulation to be 'high-line' for the day and for the season is extreme. The number of barrels caught by each man is carefully noted, for upon his relative success depends his proportion of the proceeds of the voyage, and his reputation as a fisherman. In a single day a high-line fisherman has caught from ten to fifteen barrels, and since each barrel contains from 150 to 200 mackerel, the rapidity of the men's movements throughout the day may be estimated. In seven or eight hours' fishing he has probably lifted over the side 2,000 to 3,000 fish, to say nothing of throwing over his jig and bringing it back empty almost as many times more. Such cases as this are exceptional, since mackerel rarely continue biting long enough to allow such a number to be taken. At the same time, when a much smaller number is caught, the activity of the fishermen is something to be wondered at. The confusion and excitement is increased by the frequent snarling of the lines and the attempts to straighten them out again." "Each expert fisherman has ten or twelve lines in his berth, and changes from one to the other according to the rapidity with which the fish are biting, or the strength of the wind. Much experience and skill are necessary to enable the fishermen to make these changes understandingly. Little is said while the fishing is going on; the men lean far over the rail in strange attitudes of expectancy, with one or two lines in each hand, the hands moving up and down and constantly hauling in or throwing out one of the lines at a time. When it is necessary to haul in one of the lines, the others are allowed to drop upon the rail."

Now and then, gentlemen of leisure with piscatorial leanings, attracted by the tales of the pleasure and excitement of mackerel fishing, ship for a voyage, and for the first few minutes may delight in the glories of successful angling, but such crowding to be caught as has been just described has not been experienced by the ordinary angler. Fatigued arms and maimed hands soon compel the novice to desist from what has ceased to be a pleasure and become an onerous task. The hardening process of much manual labor must fit the apprentice to endure the strain of active mackerel-fishing.

After the catch comes the care and cure of the fish. The men engaged in dressing are divided into gangs, each of which is usually composed of three men. Each gang has two wooden trays, about three feet square, and six to eight inches deep, and these are placed on the tops of barrels. One of these trays is the "gib-tub" or "gib-keeler," and the other the "splitting-tub" or "splitting-keeler," of the mackerel men's nomenclature. "Except on the seiners, the mackerel when caught, are put into barrels, and the splitting is done upon a board laid across the top of the barrel, rather than in a 'splitting-tub.' One man of each gang splits, the other two gib, or eviscerate the fish. The tub of the man who splits, of course, contains the fish to be split. With a scoop-net, the splitter, or one of the 'gibbers,' from time to time, fills the splitting-tub from the piles of mackerel lying upon the deck. On the side of the splitting-tray, next to the 'gibbers,' is a board about six to ten inches wide, called a 'splitting-board,' on which the splitter places the fish." As he cuts them open, "he takes them in his left hand (on which he has a mitten) round the centre of the body,

head from him, and, with the splitting-knife, splits them down the centre of the back. As fast as he splits the fish, he tosses them into the tray of the 'gibbers.' The 'gibbers' protect their hands with gloves or mittens. As fast as the 'gibbers' remove the viscera, with a peculiar double motion of the thumb and fingers of the right hand, they throw the fish into barrels, which are partially filled with water; these are called 'wash-barrels.' If the men have time, they 'plow' the fish before salting them, making a gash in the abdominal cavity, nearly to the skin, with the peculiar knife, 'the plow,' provided for the purpose. Before the fish are salted, the dirty water is poured out, and clean water is added. About one barrel of salt is used for every four barrels of mackerel. This is the first salting. When the fish have been salted, they are placed in unheaded barrels, until the weather is unfit for fishing, or the deck is filled with them, when they are carefully heaped up, and stowed away below."

Later, the fishes are graded. The details of this selection vary in the different states, but in Massachusetts there are five qualities which are called Nos. 1, 2, 3 large, 3, and 4, commencing with the best, and grading downwards. Grade "Number One" is reserved for mackerel of the best quality, and must be unmutilated, free from rust, taint or other damage, and not less than thirteen inches in length, from the snout to the fork or crotch of the tail; "Number Two" are likewise free from damage, and measure not less than eleven inches in length; "Number Three large" is composed of those that remain, if free from taint or damage, which measure not less than thirteen inches in length; "Number Three," also undamaged, must be not less than ten inches long; "Number Four" includes all other mackerel free from taint or damage. In addition to these regular grades, required by the law, dealers are accustomed to resort the legal grades into other combinations, "Extra One," "Extra Two," and "Mess mackerel." "Mess mackerel are made from any grade, but principally from numbers Two and One fish, free from the heads and tails, and with the blood scraped off."

We must now hasten to the consideration of other members of this interesting family.

Two other species of mackerel occur, but much less abundantly, along the eastern coast. They are nearly related to each other, and contrast with the commercial mackerel in the possession of several characters in common; an air-bladder is present, and moderately well developed; the head, above, has a large conspicuous area, transparent in life, but which, in alcohol, assumes a whitish appearance; the scales about the pectoral fin are enlarged, and form a sort of corselet, and the dorsal spines are reduced in number to nine, or, rarely, ten. *Scomber pneumatophorus* and *Scomber colias* are the scientific names which have been given to the two species of this section. They have been confounded under the popular names chub-mackerel, tinker-mackerel, easter-mackerel, &c., and frequently they may be mistaken for the common mackerel. The *Scomber pneumatophorus* has the sides below silvery, and destitute of spots. The *Scomber colias* has the sides below marked by very numerous, roundish or oblong, dusky olive blotches.

The *Scomber colias*, in addition to the names just mentioned, rejoices in several others, such as big-eyed mackerel, and bull mackerel; from *Scomber scombrus* it is readily distinguishable by the row of roundish or sub-circular spots upon the sides, below the lateral line, and it is considerably smaller than the commercial species. It is very erratic in its movements, at some periods coming upon the American coasts in immense numbers, and then again it may be entirely absent for years.

Frigate-mackerel is a popular name, borrowed from the Bermudians, that has been

given to a scombrid, intermediate to some extent between the true mackerels, *Scomber*, and the bonitos. The body is much stouter, but the spinous dorsal is short and distant from the second as in *Scomber;* the pinnules are more numerous, there being eight above and seven below; the teeth are very small, and the vomer and palatines are destitute of any; the corselet is much more developed than in *Scomber;* the back is blue, and the belly silvery. The species attain a size of from about twelve to sixteen inches, and a weight of three quarters of a pound to a pound and a half or more. *Auxis thazard* is the scientific name of this species.

Its range is chiefly in the tropical Atlantic, but it is quite erratic in its movements, and frequently ascends far northward. It is only within a few years, however, that it has been observed along the eastern coast of the United States. They associate together in large schools, — sometimes in immense numbers, — and, in the words of one very practical observer, as many as one thousand barrels would be obtainable from a school. There are, it is to be added, about eighty to one hundred to a barrel. It was noticed, on one occasion, that a day after the appearance of this fish, the common mackerel disappeared, but, whether the latter were driven away by them, or not, was not determined. They feed on the so-called mackerel food. "They are very easy to catch, flip like menhaden, do not rush, and are not frightened at the seine." The value as a food fish is not great, for the flesh behind the gills is black and rank, although in the posterior part of the body it is white, and "the meat near the back-bone is said to be of disagreeable sour flavor." It is therefore much inferior to the mackerel or bonitos. There is, indeed, in the words of Mr. Goode, little probability that "its advent will be of any special importance from an economical point of view, for its oil does not seem to be very abundant, and it will hardly pay, at present, to capture it solely for the purpose of using its flesh in the manufacture of fertilizers."

The bonito of the American markets, or the belted bonito of others, *Sarda mediterranea*, has a very robust fusiform body, a long spinous dorsal with about twenty-one spines, eight pinnules above and seven below, largish compressed teeth in the jaws and palatines, toothless vomer, and a good corselet. The color is a dark steel-blue above, silvery below, and, what is characteristic, there are dark stripes running obliquely downwards and forwards. It is a common pelagic fish, and approaches the coasts of both sides of the Atlantic in summer. As a food fish it is of little value.

We may now consider one of the most important of economical fishes as well as the largest of all fishes, the tunny, *Orcynus thynnus.* The contour is fusiform and full; its spinous dorsal fin is long and armed with twelve to fifteen spines, which gradually decrease in length backwards; the second dorsal and anal are rather short and high, and behind each are eight to ten finlets; a very distinct corselet is developed, and the body behind has smaller scales; and palatines as well as vomer have small crowded teeth. In addition to these general characters, the pectorals are rather short and do not extend beyond the end of the spinous dorsal, and the color is dark blue above and grayish below, with silvery spots. While tunny is the commercial name, and that by which it is generally known in the books, it is called by various other names, and is the horse mackerel of the Massachusetts coast.

As has been just mentioned, it is the largest of the bony fishes. It has been asserted by an Italian naturalist, Cetti, that it occasionally attains a weight of fifteen hundred pounds, and in America, according to Prof. Goode, its weight is not unfrequently twelve to fifteen hundred pounds. Such a size as the maximum, however, is extremely unusual. In the Mediterranean, where systematic fisheries are established, a fish of five

hundred pounds is considered a very large one and two hundred pounds is about the average. One specimen taken in 1858 off Cape Ann measured, according to Dr. Storer, fifteen feet in length, and weighed one thousand pounds, and in 1878, Capt. Henry Webb, off Milk Island, Gloucester harbor, killed thirty of these monsters, weighing in the aggregate at least thirty thousand pounds. But according to Capt. Atwood the average size is about eight feet in length, and this, on the basis of the ratio of length to weight recorded by Dr. Storer, would give only about one hundred and fifty pounds weight or little more. These data of length and weight require revision.

The tunny ranges in the warm temperate Atlantic zone, and is common to both sides of the ocean. It is especially abundant in the Mediterranean, and ascends along the coast of Europe sparingly to the Lofoden Islands in latitude 69°, while in the western Atlantic, along the shores of America, it may be seen as far north as the Gulf of St. Lawrence and Newfoundland in the summer.

Mr. Goode informs us that, although abundant at some seasons of the year off particular parts of the coast, it is not a familiar form to our writers. It is a summer fish,

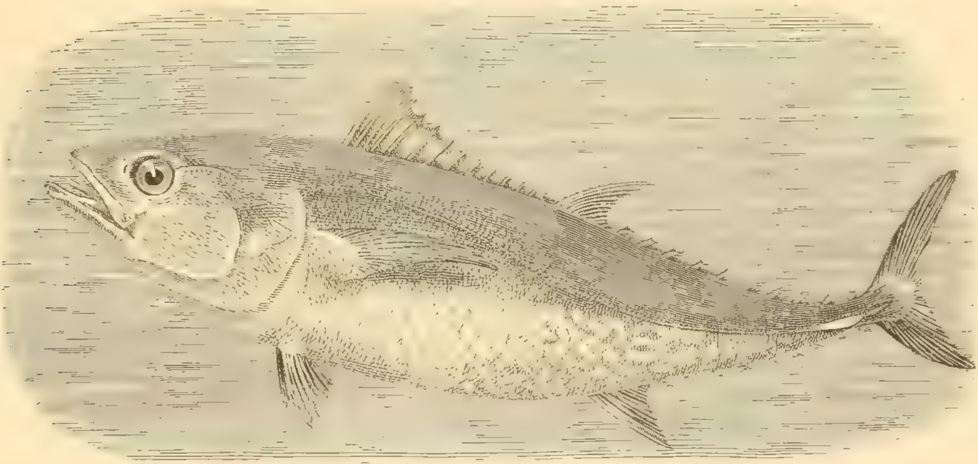


FIG. 115. *Orcynus thynnus*, tunny, horse-mackerel.

and makes its first appearance on our shores, about Provincetown, early in June, and remains until October; of late years it has been increasing in abundance northward, becoming more and more common, during the summer season, about Newfoundland.

The tunny, gifted with surprising strength and power of swimming, is a formidable foe to other fishes, and has been denounced as an enemy of all kinds. It has been seen to swallow small sharks, such as the dog-fish, weighing about eight pounds, and when dog-fishes, caught for the liver, have been eviscerated and thrown back, the tunnies would immediately catch and eat them. It is also the well-known enemy of the dolphin, as well as of the favorite prey of the latter, the flying-fishes.

The flesh of the tunny is dark, and not attractive to the eye, and yet it is not only wholesome, but is much esteemed in southern Europe, although held in very slight favor, or even in disfavor, in the United States. In America, in fact, it is scarcely ever eaten fresh, and it is only caught for the oil which it furnishes. A large fish may yield as much as twenty-three gallons of oil, although the average is much less. But,

although the fresh fish is rarely used in the United States, the fish canned is imported from Mediterranean ports.

In the waters of the United States, the tunny is chiefly caught by harpooning, and is rarely captured in nets. Indeed, special nets have to be provided for it, as, on account of its form and vigor, it readily breaks through ordinary ones. Capt. Atwood has told us that "when they strike a net, they go right through it, and when they go through, the hole immediately becomes round, but the fishermen do not dread them much, because they do the net so little injury, for the hole that they cut can be mended in about five minutes." In the Mediterranean, however, special nets are provided, and the tunny is the object of a fishery of prime importance. One mode of capturing them has been described in a very graphic manner by Professor Quatrefages, and a transcript of his account will doubtless be welcome.

"The most formidable means devised for capturing this unfortunate fish is undoubtedly the madrague, which is said to have been first employed by the inhabitants of Martigues. . . . The madrague is an actual park, with its walks and alleys all terminating in a vast labyrinth, composed of chambers which open into one another, and all of which lead to the chamber of death, or the corpon, which is situated at the extremity of the structure. This vast enclosure, the walls of which sometimes extend upwards of three miles, is both secured and raised by means of immense lines and nets weighted with stones, supported by cork buoys, and secured with anchors in such a manner as to resist the most violent storms to which it would be exposed during the usual fishing season. It may easily be conceived that the materials constituting an apparatus of this kind are of enormous size and bulk; on this account, a steamboat is chartered every year to convey the entire apparatus from Palermo to Favignana. The arm of the sea which lies between this island and Levanyo is peculiarly well adapted for the establishment of a tonnara, as the Sicilians call it, and the right of fishing in this locality alone is valued at 60,000 francs."

On one occasion Professor Quatrefages went on the steamboat to the fishing-grounds. By the break of day all the craft for miles around were to be seen converging toward the same point, and in a short time they surrounded and enclosed "a space of about one hundred square feet.

"Between 500 and 600 tunnies, impelled from chamber to chamber by the valves which close behind them, have at length reached the last compartment, or the chamber of death. This enclosure is provided with a movable floor formed of netting, which can be raised from the bottom to the surface of the water by means of ropes. All night long, men have been laboring to lift the huge apparatus, little by little, and now each of its margins rests upon the sides formed by the boats. Facing us is the proprietor of the fishery, surrounded by his staff, and by a charming group of ladies who have come from Palermo to witness the spectacle which is about to be exhibited. To the right and to the left are stationed the two principal boats, which convey the band of fishermen. These boats, which are entirely empty, lie ready to receive their cargo; the only thing that breaks the even line of their decks being a long beam, which passes from one extremity to the other, and leaves a narrow sort of gangway on the edge of the boat, where stand at least two hundred fishermen, who have come, in some cases, from a distance of more than fifty miles to take part in this exciting sport. Half naked, with deeply bronzed limbs, these athletic men stand side by side, all awaiting with the same eager impatience the moment of action. Their eyes are sparkling beneath their scarlet Phrygian caps; their hands are grasping the imple-

ments of death,—broad, sharp, and cutting hooks, which are either inserted into a long pole, or fitted to the end of a short massive handle, which is deeply cut to enable the hand to obtain a firmer hold of the weapon. In the midst of the enclosure, a little black rowing-boat, manned by two oarsmen, contains the master-fisherman, from whom emanate all orders, and who is ever at hand to encourage and lead on the workmen, or to carry reinforcements from side to side, as they may be needed.

"During all this time the capstans, which are fixed at the extremities of the net, have never ceased turning; and as the moving floor of the corpon gradually rises, the tunnies begin to appear, and, on looking through the transparent water, we see the fish darting uneasily from one side to the other of a vast enclosure in which they are imprisoned. Some of them rise to the surface, or even spring out of the water; but woe be to those who rise near one of the boats, for no sooner does one appear than hands of iron are stretched forth to bury their sharpened points in its sides. Even though they may be wounded, the fish generally escape from the first attack; for, being full of life and strength, and in the enjoyment of entire liberty of motion within the large basin that encloses them, they tear themselves from the hands of their enemies, leaving only a few bleeding shreds of flesh attached to the hooks; but still the capstan turns remorselessly to the modulated songs of the sailors, and the net rises higher and higher. The master-fisherman is always at hand in his little boat to drive the tunnies towards the edges of the net. Wounds are now dealt on every side; and soon some fish, more deeply struck than his companions, slackens his course, showing from time to time his broad silvery sides, along which the black blood is streaming forth. At every new stroke his resistance diminishes, and soon the victim pauses for an instant; but that instant is enough; a dozen hooks are at once buried in his flesh, a dozen arms are bent to lift him to the surface of the water. In vain the skin has given way; each hook that loses its hold is raised on high only to be buried still deeper in the quivering flesh; and soon the unfortunate animal is drawn to the side of the boat. In another moment he is seized by two men, who, each grasping one of his large pectoral fins, lift him to the beam which is placed behind them and throw him into the hold."

The slaughter goes on, and, after two hours of carnage, symptoms of exhaustion begin to appear, the fish almost cease to come to the surface, and the capstans are again brought into play. Soon the inner net is raised upwards to a level with the water, and "a picked crew pursue the tunnies within the narrow limits to which they are now circumscribed, and, striking them with long harpoons, urge them forward against the hooks which are projected from the boats, and which speedily secure them."

As a result of the haul, "in three hours 554 fish had been harpooned, weighing on an average 176 pounds. Besides this, the chamber of the madrague still contained about 400 captives; the proprietor might therefore count, at the very beginning of the season, upon having caught about 70 tons of the tunny fish, which would, at the least, be equivalent to the sum of 43,000 francs. Here, then, in one fishing, nearly enough had been gained to pay the whole expenses of the tonnara."

One of the most esteemed fishes of the American markets is the scombrid known in the United States as the Spanish mackerel, but very different from the so-called Spanish mackerel of England. The English fish of that name, *Scomber colias*, is closely related to the true mackerel, but the American fish so named belongs to a widely distinct genus, and is the *Scomberomorus maculatus* of American authors, and the *Cybium maculatum* of European. This fish is slender and elongated, with a small

pointed head; the spinous dorsal is low, and has fourteen to eighteen feeble spines; the second dorsal and anal are short and elevated, and each is succeeded by eight or nine finlets; the teeth in the jaws are strong and compressed, and fine teeth exist on the vomer and palatines; the color is bluish, tinged with silvery above, and along the sides are numerous round bronze spots about as large as the pupil of the eye.

In size the Spanish mackerel is smaller than most of its relatives, but the average varies. According to Mr. Goode, as a rule, the first to arrive on our coast are the largest, and measure from twenty to twenty-four inches, while those coming later are only about twelve or fifteen inches long. Specimens of thirty-six and forty inches are sometimes caught by the use of trolling-lines, but these fish are rarely found in the schools.

The Spanish mackerel is an inhabitant of the Caribbean seas and the coast waters of America, considerably to the northward as well as southward. It is somewhat erratic in its appearance, and has been much more abundant to the northward along our coast of late years than formerly. It extends northward along the eastern coast as far as Cape Cod; on the western it is not found northward of Lower California. In the 17th century it seems to have been moderately common, but for a long interval no record has been preserved of its appearance. For some years, however, it has been increasing in abundance, and is now a tolerably common fish, as well as the most esteemed for the table.

Along the Florida coasts, they are first seen in March or April, four or five miles from land, moving along swiftly towards the eastward, or playing at the surface, with no apparent aim or course of movement. Along the North Carolina coast, they become abundant in the latter part of August and September. On the Virginian, they come in August and September, and stay until frost. According to Genio C. Scott, writing in 1875, "every year the shoals of Spanish mackerel become more and more numerous, and more are taken, but never in sufficient numbers to reduce the average price below sixty cents per pound." The shoals which he saw, when last trolling for them, would have formed "an area of nearly five miles square and still the most successful did not take more than a dozen in three days. They will not bite at any artificial lures, and though numbers came near leaping on the top" of his yacht, they treated the lures with an indifference that savored of perversity.

Nothing was known concerning the reproduction of the Spanish mackerel until 1880. It was then found spawning abundantly in the Chesapeake bay, and the data respecting its varying periods of deposition along the coast were also secured by Mr. Earll. "The temperature of the water seems to have a decided effect upon the spawning time of the mackerel, and the ovaries and spermaries do not develop very rapidly until it has risen to upwards of 72° Fahrenheit." In Carolina, spawning commences in April, around Long Island in August, and in the intermediate Chesapeake region in June. The season at any one locality lasts from six to ten weeks. The eggs, when thrown from the parent, "rise to the surface, and are driven hither and thither by the winds and tides during the earlier period of development." The time of hatching varies according to the temperature, but at 40° Fahrenheit almost all the eggs are hatched, and the young feed within twenty hours and "fully half" eighteen hours after fecundation.

Passing over the numerous other species of the family, still other forms related, but more distantly, deserve attention.

Among the Scombridæ we find fishes which exhibit different tendencies, finding

their culmination in forms that are now so isolated by reason of the loss of intermediate types that they are distinguished as peculiar families. Among the Scombrids in question is the genus *Acanthocybium*, which exhibits, in its elongated spinous dorsal fin, and projecting jaws, as well as the structure of the gills, characters which tend towards the sword-fishes. Another specialized group is that represented by the elongated compressed species in which the spinous dorsal is also elongated, and in which the ventral fins become feeble or obsolescent. These lead naturally to another group of fishes which apparently are worthy of differentiation into two distinct families. First, we may consider the sword-fishes, and afterwards the ribbon-like Scombroidea.

The Scombroidea with the upper jaw elongated and condensed into a sword-like weapon have generally been combined in one family, but the differences manifested by the species are so great as to demand a recognition of two distinct families, the Histiophoridæ and the Xiphiidæ.

The sail-fishes or bill-fishes, constituting the family Histiophoridæ, have the body elongated and more or less compressed; the spinous dorsal fin is very long and persistent, and often greatly developed, the spines being elongated, connected by membrane, and constituting the sail of the fishermen, and the ventral fins are present in the shape of elongated compressed spines, and generally have one or two axillary rays; but the chief differences are exhibited by the skeleton, prominent among which are the elongated hour-glass-shaped vertebræ, flag-like neural and hæmal spines, and the well-developed ribs. Two distinct genera are represented in the American seas. The spear-fish or bill-fish, *Tetrapturus albidus*, is a form having the dorsal fin low or moderately developed, and the ventral fins are represented only by the spines. It is an inhabitant of the American seas as far north as the New England waters in the summer months, and is not rarely taken by those engaged in the sword-fishery. Occasionally, also, they enter into the fish-pounds along the coast. In the tropical waters, however, the horizon of the species, according to Professor Poey, is at a depth of about a hundred fathoms. It is probable, then, that the temperature guides their movements, and that it is an inhabitant rather of the cooler waters than of the true tropical ones. It is noted for its antagonism to sharks, and the fish is said to become furious at their appearance, and to engage in violent combats with them.

Fig. 116.— *Histiophorus gladius*, sail-fish, young.

The sail-fish, *Histiophorus americanus*, is scarcely distinct from the *H. gladius*, but is distinguished from the *Tetrapturi* by the greatly elevated spinous dorsal fin, and by the development of two or three rays within the axils of the ventral spines. This species is also a summer inhabitant of the American waters as far north as New England, and is likewise occasionally taken by the fishermen. It is, however, so active in its movements that its value scarcely compensates for its capture.

The true sword-fish is the only representative of the family Xiphiidæ. The body is shorter, much stouter, and less compressed than in the Histiophoridæ, the spinous dorsal becomes atrophied behind, the posterior spines being scarcely visible, and ventrals are entirely wanting. But it is more especially distinguished by the larger short vertebræ, the spiniform neural and hæmal spines, and the development

of only a few short ribs; the soft fins are also peculiar in being so invested in the skin as to leave the rays almost indistinguishable, and to remind one of the fins of sharks rather than those of ordinary fishes. It is the object of extensive fisheries both in the Mediterranean and along the New England coasts, and has been made the subject of an elaborate report by Professor Goode, which furnishes us with some interesting data. From time immemorial it has been known to the dwellers around the Mediterranean, where it is quite common; and individuals occur in summer, but more and more sparingly as they approach the north, even as high as Norway; and along the American coast it advances northward at least as far as Halifax. It is likewise found in the Pacific, and has been recognized along the coast of California,

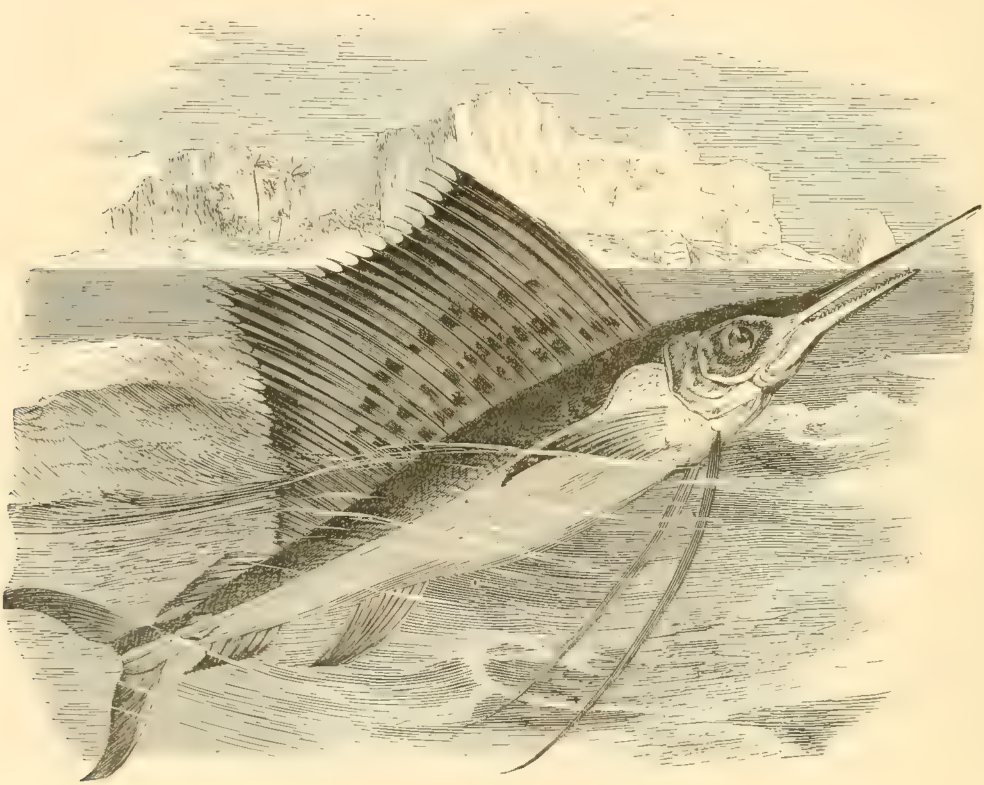


FIG. 117.—*Histiophorus gladius*, sail-fish, adult.

and in the southern hemisphere its presence about New Zealand has been recorded. Its appearance seems to be determined chiefly by temperature, and it is generally first seen on the coast from New Jersey to New England about the last of May or early in June, and remains in those waters until September, or when the first cold winds drive it off. It is said to be seen only on quiet summer days in the morning before ten or eleven o'clock, and in the afternoons about four o'clock, and fishermen say that it rises when the mackerel rise, and when the mackerel go down the sword-fish also goes down. When they first appear, the fishes are very poor and lean, but as the summer advances they grow fat. The first are comparatively of small size, averaging about one hundred and fifty pounds gross, and of a length measuring about four feet; but later and

further to the eastward much larger ones are found, weighing from three to eight hundred pounds gross, and of a blackish color. They come and leave in a general school; not in close schools like other fish, but distributed over the surface of the water, the whole being called by the fishermen the annual school, though it cannot strictly be so named. Indeed, according to Professor Goode, it is the universal testimony of our fishermen that two are never seen swimming close together, and Captain Ashby maintains that they are always distant from each other at least thirty or forty feet. The sword-fish appears to spawn at quite a distance from the coast. The eggs float to the surface and then quickly mature. The young are very different from the old, and indeed would not be recognized by an inexperienced observer, and would even be referred to a very distinct group of the class. According to Mr. Goode, little is known about the rate of growth. Young fish in the Mediterranean, ranging in weight from half a pound to twelve pounds, are thought to have been hatched during the previous summer; those of a larger size, ranging from twenty-four to sixty pounds, taken on the New England coast in the summer, are perhaps the young of the previous year. "Beyond this, even conjecture is fruitless. As in other species, the rate of growth depends directly upon the quantity of food consumed."

The sword-fish is rather indiscriminate in its food, and almost all fish it comes across are meat for it. It feeds on "menhaden, mackerel, bonitos, blue-fish, and other species which swim in close schools." It is said to "rise beneath the school of small fish, striking to the right and left" with the sword until a number have been killed, which it then proceeds to devour. "Menhaden have been seen floating at the surface, which have been cut nearly in twain by a blow of the sword." It is also recorded that fish have been thrown out into the air and caught on the fall by it. Capt. Ashby has asserted that he has seen a school of herring congregated together "at the surface, on George's Bank as closely as they could be packed," and "a sword-fish came up and through the dense mass, and fell flat over on its side, striking among the fish with the sides of its sword." He has at one time picked up "as much as a barrel of herrings thus killed by the sword-fish on George's Bank."

The flesh of the sword-fish is somewhat oily, but nevertheless a very acceptable article of food. According to Professor Goode, "its texture is coarse; the thick, fleshy, muscular layers cause it to resemble that of the halibut for consistency. Its flavor is by many considered fine, and is not unlike that of blue-fish. Its color is gray. The meat of the young fish is highly prized on the Mediterranean, and is said to be perfectly white, compact, and of delicate flavor. Sword-fish are usually cut up into steaks, thick slices across the body, and may be boiled or broiled. Considerable quantities of sword-fish are annually salted in barrels in Portland, Gloucester, Boston, New Bedford, and New London. Sword-fish pickled in brine is in considerable demand in some parts of the country, and particularly in the lower Connecticut valley, where a barrel may be found in almost every grocery store. By many persons it is considered much more eatable than salted mackerel."

The sword-fish along the New England coast is hunted for in special vessels of small size with a prominent platform at the bow, on which the harpooner is stationed. It has been estimated by Mr. Goode, that "the average weight of a year's catch of sword-fish amount to 1,500,000 pounds, valued at $45,000, the average price being estimated at three cents per pound."

The tænioid fishes are closely related to the elongated Scombridæ, but exhibit differences which may be properly used, not only for family distinction, but further

subdivision. All of them are elongated and very much compressed, resembling, as the name tænioid indicates, a band or ribbon; the lower jaw is more or less prominent; large barbed teeth arm the jaws; the dorsal fin is very long, and generally the spinous portion merges into the soft without any break; the anal fin proper is short, but preceded by numerous rudimentary spines intervening between its commencement and the anus, and the ventrals are represented by scale-like spines or entirely wanting.

The scabbard-fishes, LEPIDOPIDIDÆ, are those forms which have a distinct and tolerably developed, though small, caudal fin, and whose pectoral fins are modified in a curious way, appearing to be inserted wrong side upwards, for the lower rays are longer than the upper, and diminish upwards. There are at least four genera of this type known. The species are inhabitants of tolerably deep waters.

The true scabbard-fish, *Lepidopus argenteus*, has a pointed head, and is of a beautiful silvery color. The species is interesting on account of its distribution. It is found

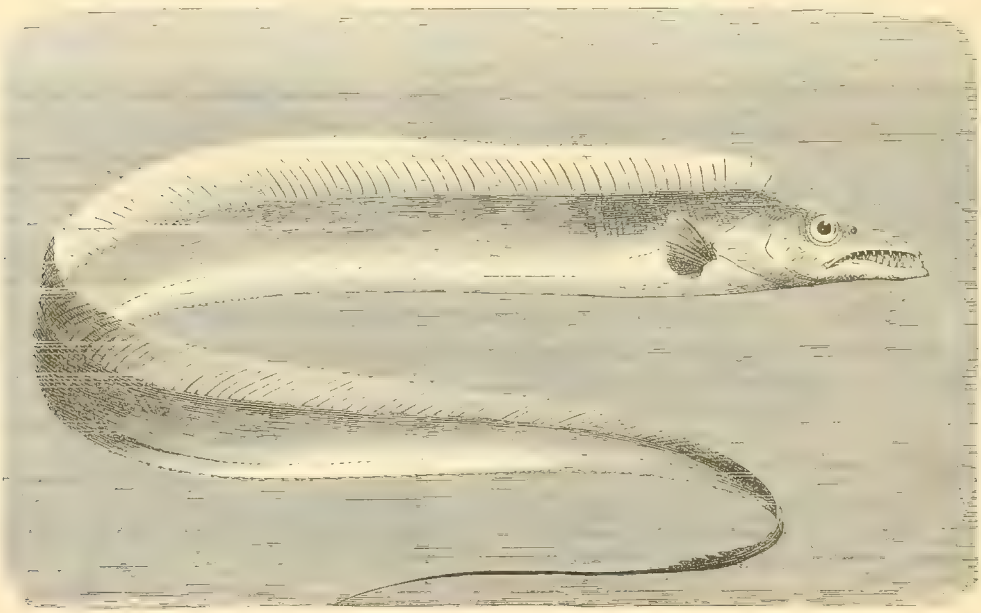


FIG. 118.— *Trichiurus lepturus*, thread-fish, cutlass-fish.

in deep water in the Mediterranean and along the coast of Europe, but more sparingly northward. By the English fishermen it is called the scabbard-fish; it is, however, quite rare, and not a regular food-fish of the English. In the southern hemisphere it reappears, and after heavy storms is cast ashore on New Zealand about the season when the frost commences, and for this reason is called the frost-fish. It is regarded in New Zealand as being at least one of the best food fishes of the colony; in the words of Dr. Hector, even " the most delicious fish in New Zealand."

The hair-tails or cutlass-fishes constitute the family TRICHIURIDÆ, and, as the name indicates, have the posterior part of the body elongated and almost hair- or thread-like, and, of course, it is destitute of a caudal fin; the pectoral fins are of the normal type of structure, and present no distinctive characteristics.

The common thread-fish, perhaps better known as the cutlass-fish or sabre-fish, *Trichiurus lepturus*, is quite widely diffused in the tropical and temperate Atlantic

seas. It may be at once known by the long filiform tail, and by its beautiful silvery color. In allusion to the color it is sometimes called, along the southern coast, silver-eel, and still other names are given, such as skip-jack in the Indian river region, and sword-fish about Pensacola. It grows occasionally to a length of four or five feet, but is not often seen more than two or two and a half feet long. It is very rarely met with along the European coast and apparently does not enter the Mediterranean. It swims along the surface of the ocean, and, as one of the names (skip-jack) indicates, is prone to leap out of the water. Several instances were related to Professor Goode of this fish throwing itself from the water into row-boats, and a small one fell into a boat in crossing the Arlington River where the water is nearly fresh. In some parts of Florida and Jamaica it is taken in sufficient numbers for the table, and is esteemed as a very good food-fish. It is generally caught with a hook, and the fishing takes place before day; the "lines are pulled in as fast as they are thrown out, with the certainty that the cutlass has been hooked. As many as ninety boats have been counted on this fishing ground at daybreak during the season," all hauling in the fish.

The most interesting and important of the Scombroidea have now been noticed, but there are many forms that have been placed with the families enumerated or in distinct ones near them: of such the NEMATISTIIDÆ, BRAMIDÆ, PEMPHERIDIDÆ and DREPANIDÆ really appear to be closely related to one or other of the forms described. Others seem to be more distant, and such are the TETRAGONURIDÆ, EQUULIDÆ, LAMPRIDIDÆ, LUVARIDÆ, MENIDÆ, GRAMMICOLEPIDIDÆ, KURTIDÆ, CAPROIDÆ, and ZENIDÆ. Only a few of these can be noticed.

The family TETRAGONURIDÆ has been established for a single species which is so different from all others that it is not even plain to what it is next of kin. By Dr. Günther it has been associated with the Atherinidæ, but the best ichthyologists are disposed to place it near the Scombridæ. The form is somewhat like that of some of the Scombridæ, but the scales are peculiar, in being traversed with several keels or striæ; the lower jaw is deep, and both the upper and lower have uniserial compressed teeth; the dorsal is double, the spines feeble, and the rayed about as long as the spinous portion; the ventrals are slightly behind the breast. The only species, *Tetragonurus niger*, is a moderately deep water inhabitant of the Mediterranean and Atlantic.

There is a fish of large size and very brilliant colors, whose home seems to be the temperate high-seas of the Atlantic; it is, however, not unfrequently thrown upon the English shores, and has also, but very rarely, been taken on the American. The species has received the popular name of opah, and king of the herrings, the scientific name *Lampris guttata* or *luna*, and is the type of family LAMPRIDIDÆ. The generic name, derived from the Greek *lampros* (radiant), indicates its brilliant colors. The body is much compressed and oviform, and has very minute scales. The head is comparatively small, and somewhat pointed or beaked forwards; the mouth is small and toothless; the premaxillaries are very protractile; there is a single long and falciform dorsal fin destitute of true spines; the anal is likewise long, but not at all falcate; the ventral fins originate considerably behind the pectorals and are, in position at least, sub-abdominal, being pushed backwards by the great development of the scapular arch; they are remarkable for the numerous (13) rays.

The color has been described as "a rich brocade of silver and lilac, rosy on the belly; everywhere with round silvery spots; head, opercles, and back with ultramarine tints; jaws and fins vermilion." The flesh is reddish and somewhat resembles in

appearance, as well as taste, that of the ordinary salmon. It reaches quite a large size, having been found at least four feet long.

Another small group of fishes is represented by the John Dory, or, as the name is sometimes shortened, dory of the English. The group is of family value, and has been named ZENIDÆ or CYTTIDÆ. The body is much compressed, and rhombiform or sub-oval in contour, sometimes extended toward the base of the ventrals, and the profile is nearly rectilinear, and declivous from the dorsal to the mouth; the head is extended forwards and short behind, the eyes being very near the occiput; the jaws are quite extensile, and the mouth moderately large; there are two dorsals, the

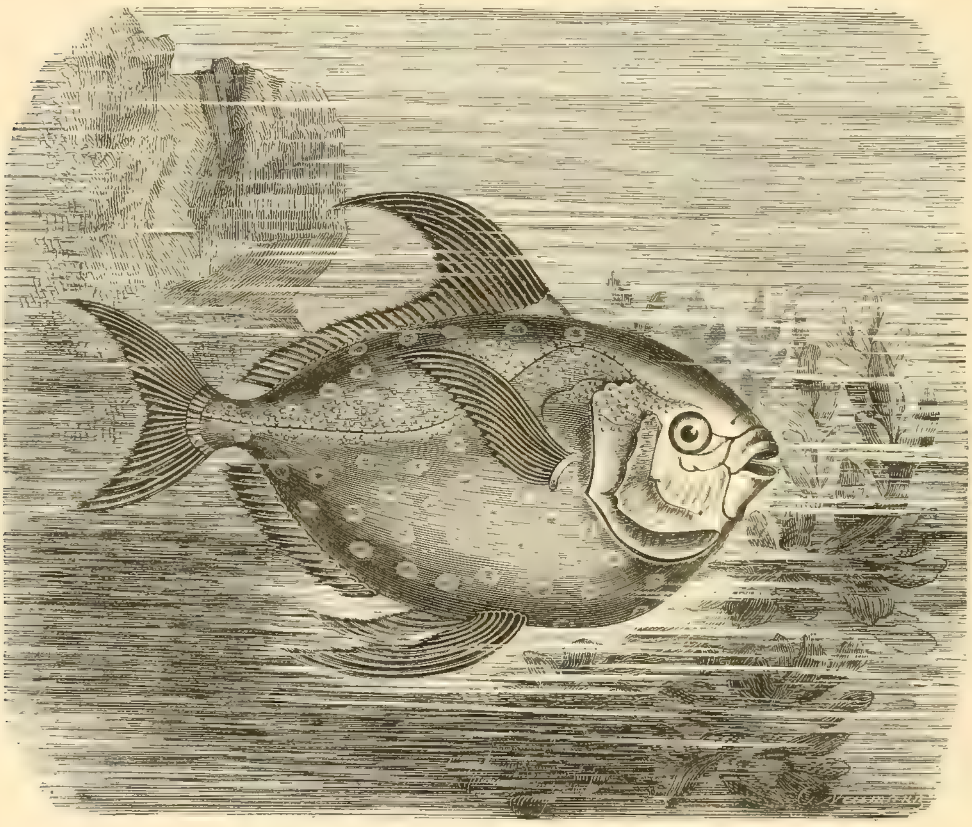


FIG. 119. — *Lampris guttata*, opah, king of the herrings.

first having eight or ten spines, and the second being long and low; the anal fin is larger even than the second dorsal, and the anus consequently advanced in front of the middle.

The John Dory, *Zeus faber*, is quite a common fish in the English seas, and has for a century past been held in high esteem as a food fish, on account of the fashion inaugurated by James Quin, the celebrated gourmand and actor of the last century. Some naturalists and etymologists have gone a good deal out of the way in seeking the origin of the name John Dory. One of the most recent, Dr. Günther, thinks that it is "partly a corruption of the Gascon '*jau*,' which signifies cock, 'dory' being

derived from the French *dorée*, so that the entire name means 'gilt cock.'" Common people are not in the habit of deriving names from two different and foreign languages, and we may therefore safely discard the surmise as very improbable, to say the least. Another writer derives it from the French, *jaune*, yellow, and *dorée*, gilt, but there is no indication that the fish has ever received such a name as 'jaune dorée' on the French coast, and it is very unlikely that it should have originated among the English. A more probable supposition is, that the name is a corruption of the Italian word *janitore*, by which the fish is known on parts of the Italian coast, and especially at Venice. The fish has a dark ocellated spot on each side some distance behind the head or near the middle of the body, and tradition records that it was the fish caught in Lake Gennesaret, from which the apostle Peter took the tribute-money, and that the spot is a reminiscence of the manner in which he held the fish. The names current at various places embody this tradition. It is possible that some traveler may have recognized the fish in England, and communicated the legend respecting it as well as the name, and that the latter superseded any other in the present corrupted form. As has already been indicated, the fish is an inhabitant of the sea, and since it does not dwell, and never did dwell, in Lake Gennesaret, where the holy man found the tribute-giving fish, it certainly is not the veritable fish of St. Peter. The John Dory, or dory, attains a considerable size, occasionally weighing as much as twenty or thirty pounds, but rarely more than twelve to eighteen in English waters.

A species of this family, *Zenopsis ocellatus*, was taken on one occasion near Provincetown, Mass.

The boar-fish of the English (*Capros aper*) is the type of a family (Caproidæ) related to the Zenidæ, but is not of sufficient interest to demand more than this mention.

Both the Zenidæ and Caproidæ exhibit a singular mode of locomotion. This is to a large extent effected by a "scarcely perceptible vibratory action" of the dorsal and anal fins, and they are thus enabled to steal upon their victims unnoticed, till they have approached so near that they can grab their prey by suddenly shooting out their very extensile jaws.

We may next consider a group of fishes which have generally been closely approximated to the Scombroidea. In fact, they are not very closely related, although the members of the two groups have been shuffled to some extent between each other. The fishes in question form a superfamily named CHÆTODONTOIDEA. The typical representatives have a very much compressed body, appearing to graduate insensibly into the dorsal and anal fins, on account of the extension upon those fins of the integuments and scales. The upper pharyngeal bones are much compressed, and vertically extended or lamelliform. The processes for the ribs originate low on the bodies of the vertebræ, and the anterior vertebræ and basioccipital bone of the skull are peculiarly modified. There are several families.

The Ephippiidæ constitute a small family distinguished by the limitation of the branchial apertures to the sides, and their separation by a wide scaly isthmus which extends from the pectoral region to the chin; the spinous and soft portions of the dorsal are more or less distinct; the upper jaw is scarcely protractile, and the post-temporal or uppermost bone of the shoulder-girdle has two processes by which it articulates with the cranium.

Two species of one of the genera of Ephippiidæ (*Chætodipterus*) occur along the American coast. One species, *C. faber*, extends along the eastern coasts as far north as Massachusetts, although rare in its northern extension; it is tolerably abundant along the Maryland and Virginia coasts and southwards, and is sold in the Washington

and other markets under the name 'porgie.' But it must be remembered that it is very distinct from the species so called about New York, which belong to the family of Sparids. The west-coast species is known as *C. zonatus*, and is very closely related to the east-coast form, but it does not extend as far northward on the Pacific coast as its eastern congener does along the Atlantic.

The CHÆTODONTIDÆ are fishes of brilliant colors, whose branchial apertures are continuous below, and whose spinous and soft dorsal elements are continuous; the upper jaw is generally moderately protractile, and the upper bones of the shoulder girdle have only single processes to articulate with the cranium.

The species of Chætodonts are numerous, and some are found in all tropical seas and especially about coral reefs. The colors are usually very striking, both by the contrast of the different hues and their distribution. The brighter hues are most apt to appear as lines which trend in various directions, usually obliquely, forwards or backwards, upwards or downwards, and not infrequently diagonally. The accompanying plate will give a good idea of the range of coloration, or rather its mode of distribution. The forms illustrated are three species of *Chœtodon* (*C. setifer*, *C. fasciatus*, and *C. vittatus*), two of *Holacanthus* (*H. diacanthus* and *H. imperator*) and one of *Heniochus* (*H. macrolepidotus*).

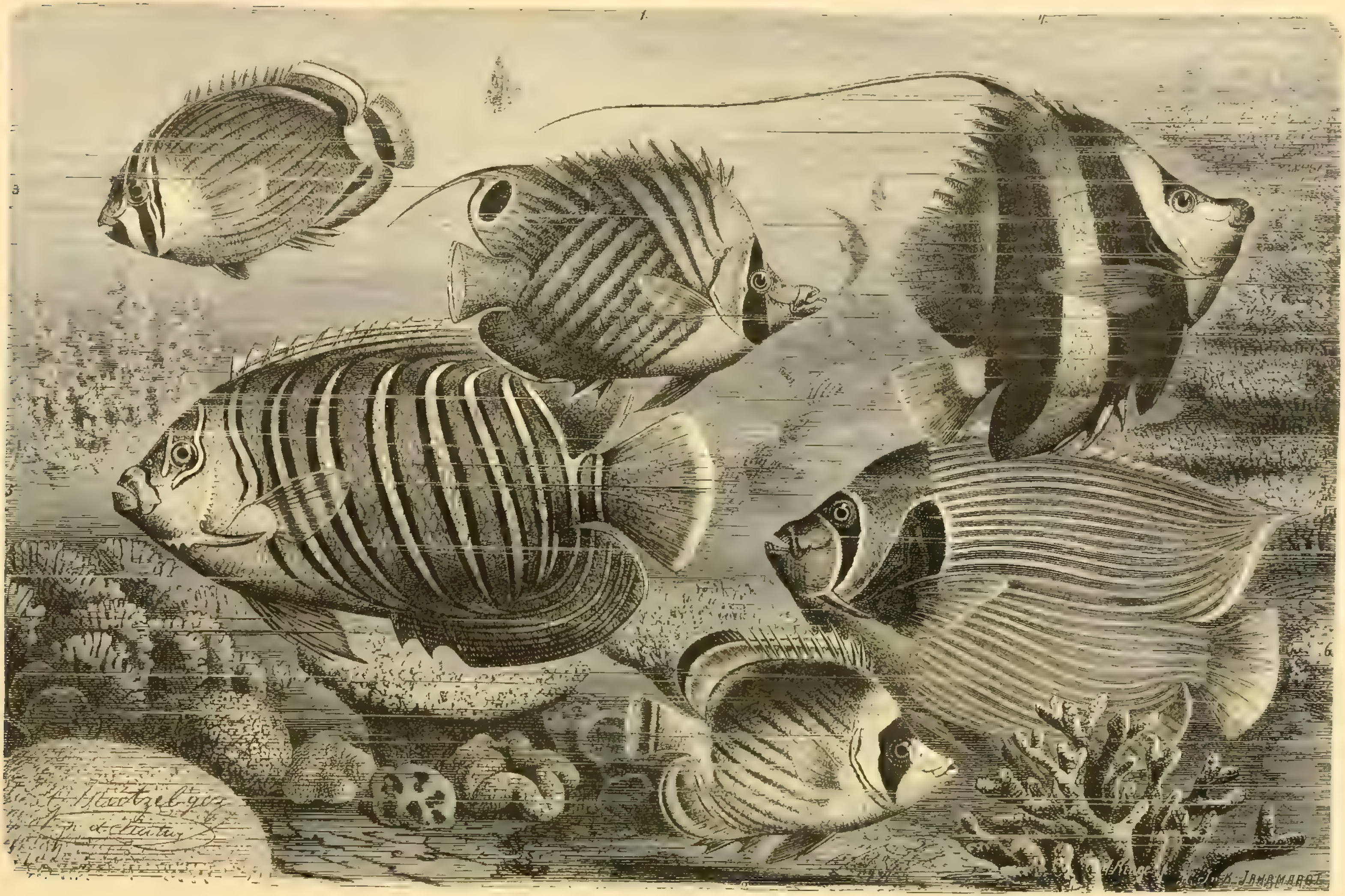
The Chætodontids are generally of rather small or quite moderate size, and not of much economical importance. There are some striking exceptions, however. The *Holacanthus imperator*, figured on the plate, called by the Dutch, "Emperor of Japan," is a fish resplendent in hues and notable for savoriness. It reaches a length of about fifteen inches, and is one of the most esteemed of all the Indo-Pacific fishes, "resembling our much-prized salmon in flavor."

The angel-fish of the West Indies and Bermudas, *Holacanthus ciliaris*, also grows to a considerable size, attaining a weight of about four pounds, and Mr. Goode thinks that "it as far surpasses all the other fishes" of Bermuda "in its delicious flavor as in its lovely hues."

ZANCLIDÆ is a family name for a single genus distinguished by the few spines of the dorsal, but otherwise nearly related to the Chætodontids. The *Zanclus cornutus*, as the name indicates, has a horn-like appendage to the forehead, and is held in great reverence by the fishermen of the Moluccas, who bow to it when taken, and then restore it to the water. Inasmuch as the fish is a very savory one, we may understand how real the reverence of the natives is.

The PSETTIDÆ, PLATACIDÆ, SCATOPHAGIDÆ, and TOXOTIDÆ have been generally associated with the Chætodontoid fishes, but they are not very closely related, comparatively, to the preceding forms. Two types that have been widely separated, on the other hand, appear to be really related, although this requires to be proved; these are the PENTACEROTIDÆ and ANOPLIDÆ. None of these, however, are of sufficient interest to demand extended notice, except, perhaps, the Toxotidæ.

The TOXOTIDÆ are fishes distinguished by the backward position of the dorsal fin and its few spines, and by the declining rectilinear outline in front of the dorsal. One of the species has been very generally credited with the faculty of shooting drops of water at insects on low-hanging branches, and thus securing them for food. There does not appear to be any adaptation in the organization of the mouth for such a feat, and skepticism must be exercised in the acceptance of the statement made. Certainly no recent confirmation of the old story has been given, and the tradition has probably resulted from some misunderstanding.



CORAL FISHES.

1. *Chætodon setifer*, eyed coral-fish. 2. *C. fasciatus*, banded coral-fish. 3. *C. vittatus*, snap-fish. 4. *Heniochus macrolepidotus*, whip-fish. 5. *Holacanthus diacanthus*, duke-fish. 6. *H. imperator*, "Emperor of Japan."

Perhaps the fishes most nearly allied to the Chætodontoidea are two families that have been associated together under the super-family name TEUTHIDOIDEA; these are the Teuthididæ and the Siganidæ. These Teuthidoidea are fishes distinguished by the development of transversely expanded, buckler-like, subcutaneous plates on the back, intervening between the spines, and limiting their erection forwards.

The TEUTHIDIDÆ comprise those fishes which have the soft portion as long as, or longer than, the spinous, only the usual external spines to the ventrals, and the head considerably produced in front of the eyes. When adult, all are armed with spines

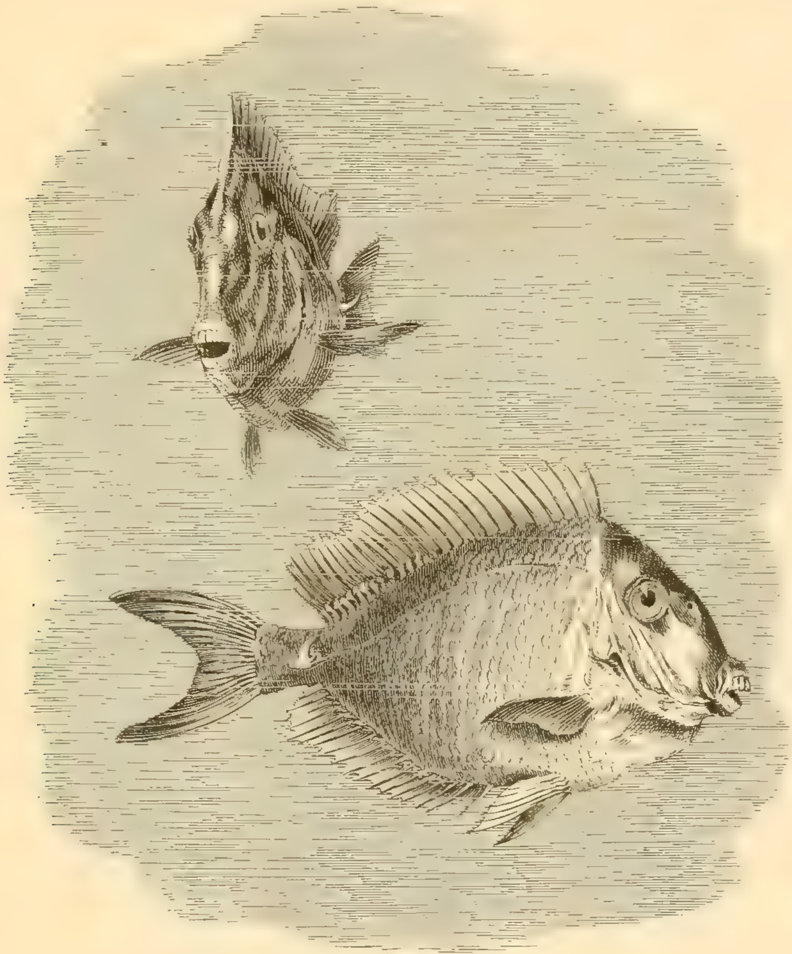


FIG. 120.— *Teuthis cæruleus*, barber-fish, surgeon.

or sharp ridges on the sides of the tail. The most characteristic have only one on each side, which is lancet-like, hooks forward, and is depressible in, or erectile from, a groove. They have received the names barber-fish, surgeon, and doctor. The appendages noticed are quite efficient weapons, and are vigorously used by the animal for offence as well as defence. If an intruder or enemy approaches too near the acanthurous tenant of a favorite spot or corner, he is met by a vigorous slash of the tail, with erected lancets, which may inflict a serious wound. In fact, all the species

so armed are quite pugnacious, and can protect themselves successfully against most enemies of their size. Three species inhabit the Caribbean Sea, and two of them ascend considerable distances up the Atlantic coast. These are the *Teuthis hepatus*, *T. cœruleus* and *T. trachis;* they are more generally known as species of *Acanthurus*.

The SIGANIDÆ are confined to the Pacific Ocean, and their homes are in the coral regions. The rayed portions of the dorsal and anal fins are equal and opposite each other, and much shorter than the spinous portions. There is a singular uniformity in the number of rays, all having thirteen spines and ten rays in the dorsal, and seven spines and nine rays in the anal fin; the ventrals are quite unique in the development of *a spine to the inner* as well as outer edges; the head is short in front of the eyes.

Between thirty and forty species of Siganidæ are known. Some have quite striking colors, disposed generally as spots or blotches.

The Teuthidoidea are the last of a series which, after a considerable but not impassable break, is resumed in forms sufficiently different in aspect, at least, to be generally considered a group of ordinal value, the Plectognathi. Before resuming consideration of the important groups, it will be well to notice a couple of small families, both of which have some importance from an economical point of view.

In the Chesapeake bay, a fish (*Elacate canada*) is found, which bears the names bonito and coal-fish, and, says Mr. Goode, is "considered one of the most important food-fishes of Maryland and Virginia, though it is but little known elsewhere." It is, however, a warm-water fish, and quite widely distributed, and it extends northward from the Caribbean sea. In eastern Florida it is called the sergeant-fish, and along the western coast of the peninsula it is known as the ling or snooks; it is the cub-by-yew of the Bermudians, a corruption of Cobia, which is a Spanish term for it. Crab-eater is a name under which it was early noticed by Dr. Mitchill. Most of the names have been used of old for better-known fishes, and sergeant-fish, or cobia, would be preferable for popular use. The dark stripes which run along the middle of the body have given rise to the name which we prefer to employ.

The sergeant-fish has been generally approximated to the Scombridæ and Carangidæ, and may be really related to the latter. It is, however, the type of a distinct family — the ELACATIDÆ — and is distinguishable by the fusiform shape, smooth scales, lateral line concurrent with the back, depressed head, free spines (eight in number) representing the first dorsal, the long second dorsal and anal, and the acutely lobed caudal fin. It is quite a large fish, sometimes reaching a length of five feet, and a weight of fifteen to twenty pounds. It is also a ravenous fish, and in Florida was observed by Mr. Clarke "lying under the mangrove bushes in wait for prey, like a pike." A specimen caught near New York had twenty spotted sand-crabs, besides several young flounders, in its stomach, and another caught in Boston harbor consumed all the fishes in the 'car' in which it was placed. The sergeant-fish is known to breed in Chesapeake bay.

Another small family, peculiar to the tropical and subtropical waters of America, is that called CENTROPOMIDÆ. These have an elongate body, small ctenoid scales, a very distinct lateral line continued on the tail, well-separated dorsals, the first with seven or eight spines (of which the third is the longest), a short anal with three spines (the second is much the strongest), and a forked caudal. The most salient peculiarities, however, are to be seen in the skeleton, and especially the posterior part of the skull.

In the English West Indian colonies the species of *Centropomus* are generally called snook, and in the Spanish robalo. The earliest known is the *C. undecimalis*, which

occurs on the Florida and Texas coasts. Although sea-fishes, most are quite at home in the fresh-water, and indeed are regarded by some as fresh-water fishes. They reach a moderate size, and are held in considerable esteem for the table. The species are all very similar in external appearance and colors.

We now commence with another series, whose parentage is perhaps the same as that of the Scombroidea, and which have been provisionally combined in the super-family PERCOIDEA.

First are fishes generally oblong and compressed, but exhibiting considerable variation in form, with scales well developed, rough, and arranged in very oblique series; the lateral line concurrent with the back and continued on the caudal fin to its end; the head compressed or inflated, and the roof of the skull more or less excavated by tunnels, channels, and holes: in the specialized types the head ends in a blunt snout overhanging the lower jaw, and such types are also provided with notches and holes above the upper lip; the mouth is moderately cleft; there are two dorsal fins, the anterior composed of a moderate number of spines, the posterior long; the anal is generally short, and armed with not more than two spines, the second of which is often very large; the pectorals have branched rays, and the ventrals are thoracic and

FIG. 121.— *Cynoscion regalis*, weak-fish, squeteague.

provided with a spine and five rays each. The constituents of this family (SCIÆNIDÆ) are numerous, and many of them are of considerable commercial importance. In Polynesia it is almost unrepresented, but elsewhere in the tropics and temperate seas has a goodly number of species; of these, eighteen occur along the Atlantic sea-coast, and seven along the Pacific sea-coast of the United States.

The weak-fish and its relations, constituting the genus *Cynoscion*, is distinguished for the forward pointed head and projecting lower jaw, and the canine teeth which are present in the front of the upper jaw. Five species occur in the United States.

The common weak-fish or squeteague (*Cynoscion regalis*) is silvery, darker above, and marked with many small irregular dark blotches, some of which form undulating lines running downwards and forwards; the dorsal and caudal fins are dusky; the ventrals, anal, and lower edge of caudal yellowish and sometimes speckled. It varies in size according to season and locality; on the coast of New Jersey, fishes do not average much more than a pound, but occasionally there and elsewhere they may be found of from six to ten pounds weight, and fishes weighing even thirty pounds have been caught. The weak-fish is essentially a coast and salt-water fish, but frequently runs up tidal waters, and seems to delight in estuaries or "the mouths of fresh-water streams where there is a mixture of fresh water." It is a resident fish in the south,

but appears on the northern coasts only in the summer, for periods varying with latitude and climate. In the Middle States its advent is quite early in the spring, but it becomes most abundant from early June to September. Its visits, however, have been occasionally interrupted, and its paucity or almost absence during some years has been attributed to the blue-fish, which is the most formidable enemy of the species. When, in past times, the blue-fish had left the coast, the weak-fish increased in numbers, and in some years it has been extremely abundant.

Although a moderately good table fish, it by no means ranks among the best, and indeed does not bring a very high price, for the flesh is soft and flabby, and of little value except when eaten fresh from the water. The weak-fish is one of the salt-water game fishes, and its pursuit is highly enjoyed by coast fishermen, on account of the great numbers that can be taken in a very short time. "They usually move about in schools of greater or less size, swimming pretty near the surface, and requiring a line but little leaded. They like almost any kind of bait, especially clams, soft crabs, or pieces of fish. These they bite with a snap, rarely condescending to nibble, and it requires constant vigilance to be prepared for them, and care in hauling them in out of the water, in consequence of the extreme tenderness of the mouth." This tenderness of the mouth is said to be the cause of the name weak-fish.

The spotted weak-fish or squeteague of the southern coast (*Cynoscion maculatus*) is like the common weak-fish in appearance, but is distinguished by the presence of numerous conspicuous round black spots upon the back as well as the dorsal fins. On account of these spots, it is very generally known in the southern states as the trout or sea-trout.

A species quite nearly related to the weak-fish is found along the southern California coast, where it is sometimes called blue-fish, although of course without any reference to the common blue-fish of the eastern coast. Its scientific name is *Cynoscion parvipinnis*. A more distant relation of the squeteagues on the western coast is a species generally known in the Californian markets as the sea-bass or white sea-bass, although the young are called sea-trout — the *Cynoscion* (*Atractoscion*) *nobilis*. This species is destitute of the large teeth which arm the front of the upper jaw of the preceding species, and is bluish above and everywhere dotted with black. It attains a much larger size than its eastern relatives, sometimes reaching a weight of sixty or seventy-five pounds, or even, but very rarely, still more; the average of those brought to the markets, however, is about fifteen pounds. "It is one of the most important food fishes of the coast. Its flesh is excellent, firm, and well flavored, and its great size renders it a very valuable species."

The genus *Sciæna* is the typical one of the family, and its best-known species, celebrated in history and common in the Mediterranean, is the *Sciæna umbra*; it is popularly known as the meagre, or maigre. The species has a very wide range; it occasionally reaches the British coast, and southwardly reappears at the Cape of Good Hope, and, it is asserted, is also found along the coast of southern Australia. It sometimes becomes six feet long or more, but of course the average is very much less.

A species related, although not very closely, to the meagre, is a fish known along the southern Atlantic and Gulf coast of the United States as the red-fish, or, as it appears in the books, branded drum or beardless drum. The most characteristic feature of this fish is the presence of a black spot margined with lighter on the end of the tail or base of the caudal fin, between the lateral line and back. It is to the presence of this spot, which is suggestive of a brand, that it owes the name of branded drum.

As to title, however, Mr. Goode thinks that this fish is very much in need of a characteristic name of its own. "Its local names are all preoccupied by other more widely distributed or better known forms which seem to have substantial claims of priority. In the Chesapeake, and south to below Cape Hatteras, it is called the drum, but its kinsman, *Pogonias chromis*, is known by the same name throughout its whole range," and is "the possessor of a much larger and more resonant musical organ: some of the old writers coined names for it, like 'branded drum,' referring to the brand-like spots upon the tail, and 'beardless drum,' but these are valueless for common use, like most other 'book-names.' In the Carolinas, Florida, and the Gulf, we meet with the names 'bass' and its variations, 'spotted-bass,' 'red-bass,' 'sea-bass,' 'reef bass,' and 'channel-bass.' Many persons suppose 'channel-bass' to be a characteristic name, but this is a mistake, for the term is applied probably only to large individuals which are taken in the channels of streams and sounds; wherever this name is used, the smaller fish of the species are called simply 'bass' or 'school-bass;' even if the word 'bass' could be so qualified as to be applicable to the species, there is an insuperable objection to its use for any fish of this family." 'Spot' is another name erroneously applied to this fish; it is "the property of a much smaller species of the same family, otherwise known as 'Lafayette' or 'Cape May goodie.' Finally we have the 'red-fish' and 'red-horse' of Florida and the Gulf States, the 'poisson rouge' of the Louisiana creoles. Although this name is occasionally applied to a much redder fish, the Norway haddock or red-perch of the north, it is, perhaps the most characteristic one, and that most suitable for general use, especially if modified into 'southern red-fish.'"

The red-fish, as we must then call it, is a large species, and may be found not rarely four or five feet long and weighing forty pounds or more, but the average weight is about ten pounds. It is regarded quite highly for table purposes, and is also the subject of pursuit as a game fish.

Another group of fishes of this family that demands some attention is that represented by the species called king-fish about New York. The group is known to the American ichthyologists as the genus *Menticirrus*, and is related to the genus *Umbrina*, of which the best known species is European, but is distinguished by a more elongated form, more backward position of the ventrals, and the absence of an air-bladder, besides some other characters. Of this genus *Menticirrus*, four species are found along the eastern American coast.

The common king-fish of the north (*M. nebulosus*) is distinguished by its color, which is bright grayish silvery, varied by dark bars of which the anterior run obliquely backward and downward, and the posterior obliquely forward and downward; the fins are dusky and spotless. In addition to the name king-fish, the species is called 'whiting,' and 'barb.' It is quite an abundant species, but of comparatively small size. They average three quarters of a pound, and the largest heard of by Mr. Goode reached the weight of only a pound and a half. It is a common market fish and is regarded as a delicious pan-fish, sweet and hard, and of delicate flavor."

A species (*M. alburnus*), common at Charleston, is related to the king-fish of the north, but differs in its teeth and color. It is also prized as a table-fish, and in Charleston it is regarded as a special dainty, and it is told that when the city was closely blockaded during "the late unpleasantness," the "commander of the garrison, who was a *bon vivant*, gave one hundred dollars of Confederate money for a string of whiting."

Along the entire eastern and gulf states of North America, and in the great rivers and lakes of the interior, are found a couple of fishes of a peculiar build and with certain salient characteristics of the pharyngeal bones. The body is much compressed and quite elevated, and rather protracted forward at the front of the back, and the lower pharyngeal bones are enlarged and joined together at the middle, forming a single triangular piece which is studded by teeth, reminding one of the cobblestones which in olden times were used for paving the streets of cities. These bones are often to be seen in collections of curiosities. The species of the type so distinguished represent two genera, one confined to the salt water and the other to the fresh. Drum is the common name given to both forms.

The drum of the salt water (*Pogonias chromis*) is distinguished by the development of numerous little thread-like appendages or barbels from the lower jaw, and the

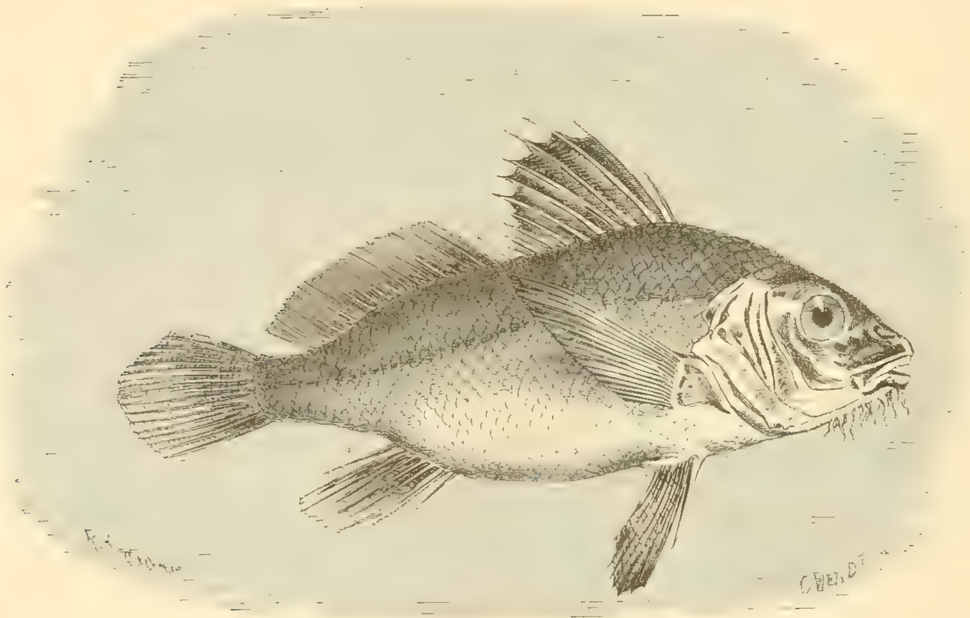


FIG. 122. — *Pogonias chromis*, drum-fish.

tail fin is emarginated or subtruncate. Its appearance is quite different according to age; when young it has four or five broad, vertical, dark bars, but with age these disappear, leaving the old uniformly colored gray silvery. The fins are also relatively larger in the young than in the full grown. The species is by far the largest of the American representatives of the family. It occasionally attains a weight of nearly one hundred pounds, but of course this is very unusual, and the average is perhaps somewhere about twenty pounds. The species is noted for the depth of the sounds, somewhat resembling those from a muffled drum, which it makes and which have obtained for it the name of drum-fish. This drumming sound is common to a large proportion of the species of the family, but is much deeper in the drum-fishes of the sea as well as fresh waters, than any of their relatives. It is said to be due, partly at least, to the action of the pharyngeal bones grinding upon each other.

The drum-fish is especially addicted to shell-fishes, and particularly mussels, clams,

etc., and it is with reference to such a diet that the pharyngeal armature is so well developed. In some places it is a source of great annoyance on account of its ravages upon oyster beds. "In New York bay, off Cabin point, where the old Black Tom reef is now converted into an island, one planter of Keyport lost his whole summer's work, material, and labor, in a single September week, through an attack by drums," and a City Island planter reported "a loss of $10,000 in one season a few years ago." The "vexation of it is, too, that the drum does not seem to eat half of what he destroys, but, on the contrary, a great school of them will go over a bed, wantonly crushing hundreds of oysters and dropping them untasted, but in fragments on the bottom."

The drum is a market fish, but is regarded as inferior in quality. Sometimes its scales are made use of in fancy work.

The drum-fish or sheepshead of the rivers and lakes (*Haplodinotus grunniens*) is also a large species, but much inferior in size to its salt-water relative. It has no bar-

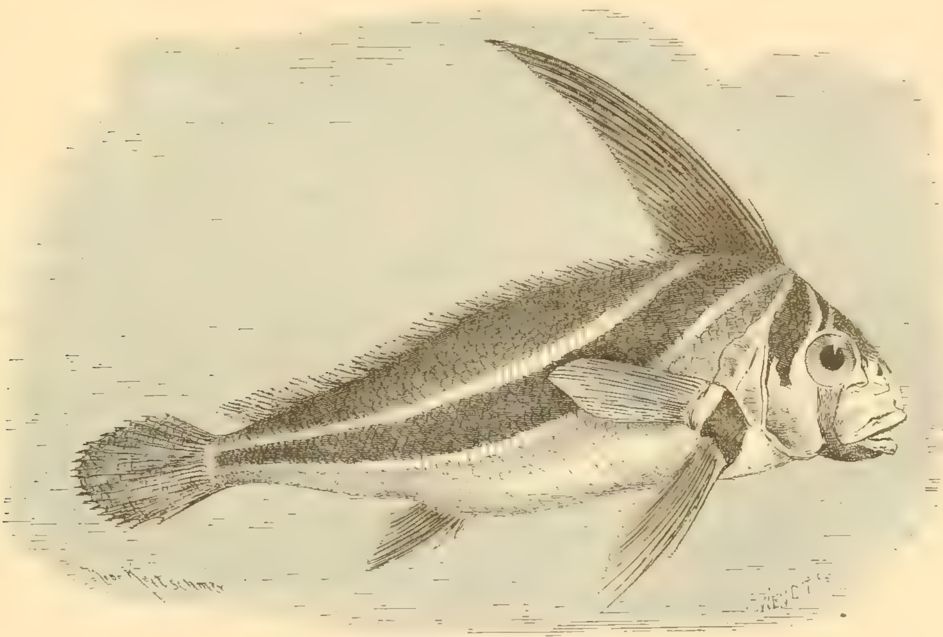


FIG. 123. — *Eques lanceolatus.*

bels to the lower jaw, and its tail is extended backward in the middle. It is a fish but little esteemed, although there seems to be some difference of opinion as to its merit, or perhaps real difference according to locality or season. Along the rivers it is held in some regard, but on the lake coast it is considered as inferior.

The least of the sciænids which we need to consider is a small fish currently known in the northern United States as the Lafayette or spot. This species is well distinguished by the absence of teeth from the lower jaw, and likewise by its coloration; it is bluish above and grayish silvery below, while about fifteen dark bands extend across the side from the dorsal obliquely forward to below the lateral line, and there is also a very distinct spot upon the shoulders. It is a small fish, but regarded quite

highly as a pan-fish. One of its common names, 'Cape May goodie,' embodies this favorable opinion of its merits. Another name, referring to the mark on its shoulders, is 'spot'; 'old wife' is an additional designation borrowed from the English. The best known name, 'Lafayette,' is due to the fact that it became prominent by its appearance and indeed was said by the fishermen to have first appeared in the year (1824) when General Lafayette visited the United States.

One other species, the *Eques lanceolatus*, may be noticed as an illustration of how much variation is compatible within the family limits of the Sciænids. This fish is one of several living in the Caribbean sea, distinguished by the humped back, very short and advanced, but elevated first dorsal, and long second dorsal, and a peculiar distribution of colors. As a rule the sciænids are very sober in coloration, but in the species of *Eques* we have some striking contrasts, as in the one here figured.

By Cuvier and the early ichthyologists, a number of fishes were referred to the family of Sciænidæ which did not really belong to it, and were eliminated by an accomplished ichthyologist, the Rev. Wm. Low, leaving it as it is now retained. Some later ichthyologists went to an extreme, and widely separated the eliminated forms from the Sciænids. Nevertheless, a number of them really do belong near that family, although still nearer others to follow. Among such are certain fishes for which the family Hæmulonidæ or Pristipomidæ has been constituted. These have the body compressed, and often (not always) elevated towards the front of the back, the spinous part of the dorsal longer than the soft, the jaw-teeth pointed, head pointed forwards, the palate toothless, and the preopercle serrate. Quite a large number of species belong to it, and a couple of genera are of special interest to the American naturalist; they are *Hæmulon* and *Orthopristis*.

Grunt, pig-fish, and red-mouth are the principal common names of the species of *Hæmulon*; the first two refer to the noise made when one is hauled out of the water, and the last to blood-red blotches on the gums or lips behind; it is to this peculiarity also that the scientific name alludes. The color of the sides is likewise noteworthy, for, in most, oblique stripes run along the rows of scales. The mouth is quite deeply cleft. The flesh is excellent.

Another fish, also called grunt and pig-fish, but differing from the former by the absence of the red staining of the jaws, and comparatively small mouth, is the *Orthopristis chrysopterus*. In some places it bears the name 'sailor's choice,' but this one is also shared by others. It is quite common on the southern American coast, and is highly esteemed; it has indeed been pronounced by some to be "the finest fish that swims."

One of the most important families of fishes is that of the Sparidæ. The body is compressed and generally quite high, especially towards the front of the back; the head is moderate, and usually the skin from the nape to the snout is smooth and scaleless; the preorbital bones are more or less enlarged, and the maxillaries slide under them; the teeth are generally developed as molars on the sides, while in front they are either conical, or more or less compressed, and sometimes shaped like the incisor teeth of mammals; the dorsal fin is long and entire, and is depressible in a groove of the back; the spinous portion is longer than the soft. The species are numerous in tropical as well as in temperate seas. On the coast of the United States representatives of six genera are found.

The typical genus of the family, *Sparus*, is represented by a species common to

Europe and the southern Atlantic and Gulf — the *S. pagrus*. It is much less abundant on the American side than on the European.

The fish called porgee about New York, and scup or scuppaug (*Stenotomus chrysops*, or, also, *S. argyrops*) in New England, is by far the most common of the Sparids along the northern coast, and extends naturally as far as Cape Cod. It may be distinguished by the very narrow and compressed incisors, and by the teeth on the sides, developed as grinders, in about two rows. The word porgee is derived from the old Latin *pagrus*, which has been modified by various European nations into different forms. Scuppaug is from an old Narragansett Indian name, and scup is an abbreviated form of it. It is a pity that the original scuppaug, or its abbreviation, scup, could not be adopted generally, but the conflict of names will probably continue. There are still other names applied to it. On the Virginia coast, for example, the name porgee is applied to the moon-fish (*Chætodipterus faber*), and this species is known as the 'fair-maid.'

The scup is one of the most abundant of the east-coast fishes in the summer, and occurs along the entire coast south of Cape Cod; specimens have indeed been found

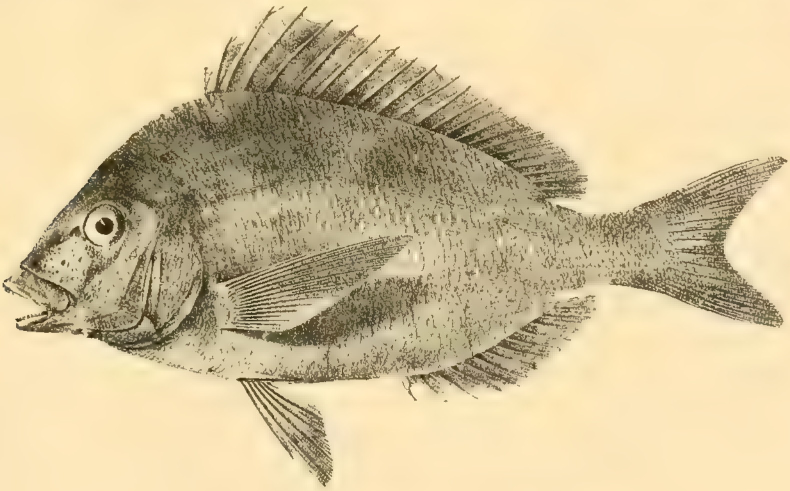


FIG. 124. — *Stenotomus chrysops*, scup, scuppaug, porgie.

north of the cape, but very rarely, and it is even claimed that they are the survivors of fishes let loose in Boston harbor in 1831 or 1832. A portion of a smack-load of live fish, it is said, was purchased at that time, "by subscription among the fishermen in the market, and thrown into the harbor." On reviewing the evidence recently, Professor Goode concluded that, judging from the rare occurrence of the species thus introduced, it can hardly be considered to have become naturalized; the few which have been taken were doubtless summer stragglers.

The scup may appear on the New England coast even as early as the middle of April, but it becomes most abundant towards the first of June, and arrives in successive detachments or runs, differing in size, the smallest fish coming last. The first run on the southern coast of New England "takes place about the beginning of May, and consists of large breeding fish, weighing from two to four pounds, and measuring up to eighteen inches or more in length. The spawn is quite well developed at that time, and is said to be at first red, but gradually to become light yellow as it

matures. The particular time and place, however, of laying the eggs is not known, although it is probable that it occurs early in June, since the schools are said to break up about the middle of that month, and the fish to scatter. It is thought probable that the spawning takes place in the eel-grass that covers the shoal waters of Narragansett Bay and Vineyard Sound." Further south their sojourn upon the coast is still longer, in accordance with the longer season. The scup grows rapidly, and when two years old is almost large enough to be marketable.

Like so many other of our fishes, the scup is variable in its abundance. At present it is much less common than it has been in times past. Of their former abundance on the south coast of New England, almost incredible accounts have been given. "They swarmed to such a degree that their capture ceased to be a matter of sport. The line, when thrown overboard, could be immediately withdrawn, with the assurance of having a fish on each one of two hooks. Any number of fishermen from boats could take from five hundred to one thousand pounds a day without the slightest difficulty, the limits being simply the ability to find a sale." At some other times, on the other hand, the fish has been even less abundant than now. Professor Baird came to the conclusion that there was good evidence to show that, prior to the year 1800, there was at least one period, if not more, when it was extremely rare. "There is a tradition that they first occurred at Newport about 1793, the sheepshead disappearing about the same time."

As a table fish the scup is moderately esteemed. Its flesh is firm and flaky, and generally it is sweet and pleasant, although sometimes a bitter flavor detracts from its palatability. In Professor Baird's estimation, the species is surpassed by very few others on the coast, although its superabundance causes it to be undervalued.

The scup is caught for the market in immense numbers in the pounds that are so numerous along the southern New England and Long Island coasts. It is also a fish that finds favor with the salt-water angler. It is generally fished for with the boat still or at anchor, and the hook is generally baited with clams. It bites rapidly, and is best secured, as soon as the bite is felt, by a dextrous movement of the hand. There are certain fishing banks near the city of New York, to which regular daily excursions are made in the summer, where the porgee and the sea-bass are the chief fishes taken.

The royal member of the family Sparidæ is the sheepshead. It may be distinguished at once by the broad cutting teeth in the front of the jaws, while its side teeth are molars or grinders in several rows, like those of the scup or porgee. The anteorbital part of the head is quite deep, and, on account of its form and color, and the teeth and manner of using them, the fish has derived its name of sheepshead. This name is the one which is common to it along the entire coast, and, indeed, it has no synonyms like almost all other species. The negroes of the south drop the middle 's' and call it sheephead.

The sheepshead occurs along the entire eastern coast, from southern Florida to Cape Cod, as well as in the Gulf of Mexico. It is perhaps most abundant in the north along the south shore of New England, and between Cape May and Montauk Point. It more especially affects oyster beds and deposits of mussels, upon which it feeds, and it is also to be found "about wrecks of old vessels, on which barnacles and shells abound." It stays mostly near the bottom, and is "quiet in its habits and little given to wandering." In the southern regions, it frequents the in-shore water during the winter season, but northward it retires from the shores in that season, putting in its appearance in the spring, and leaving in the fall, early or late, according to latitude.

In the north, in the words of an old ichthyologist, Dr. Mitchill, "he confines himself strictly to the salt water, never having been seen in the fresh rivers" about New York, and even about Charleston, Dr. Holbrook records, "it enters shallow inlets and mouths of rivers, but never leaves the salt for fresh water." But in Florida it frequently ascends the rivers and is found in purely fresh water.

Its winter quarters in the north are unknown. Professor Goode thinks that "it is not yet possible to infer with any certainty what the temperature limits of this species may be, but it would seem probable that they never willingly encounter water colder than 60°, except, perhaps, in fall, when they are reluctant to leave their feeding-grounds. The statement just made, however, requires a certain qualification. No one knows whether the sheepshead of our northern waters goes south in winter, or whether they simply become torpid, and remain through the winter in deep holes near their summer haunts, their presence unsuspected. Perhaps it would be wiser to say that they are not commonly engaged in feeding when the temperature is lower than 60°, and that their winter habits are entirely unknown. When the water is, throughout the year, warmer than 60°, they are constantly active."

The sheepshead's peculiar teeth are suggestive of its diet; it "feeds almost exclusively upon hard-shelled animals, molluscs and barnacles, and particularly on young oysters as they occur attached to stones and sticks of wood. With its strong cutting and grinding teeth, and powerful jaws, it can easily rip off thick bunches of shells, and grind them to pieces. The ordinary bait for it in the north is the soft-shelled clam, while in the south it is caught frequently by the use of shrimps and crabs."

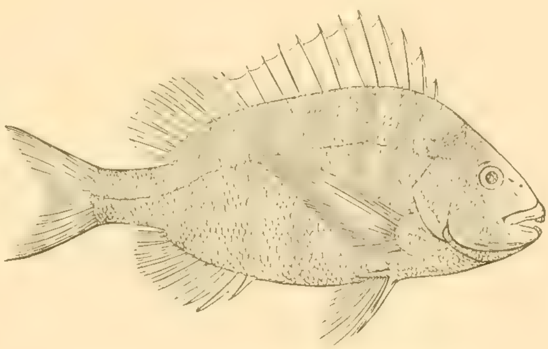


Fig. 125. — *Diplodus probatocephalus*, sheepshead.

The sheepshead is one of the favorite angle fishes, and has been esteemed as such from the early days of New York. As long ago as 1814, Dr. Mitchill wrote that "the outfitting of a sheepshead party is always an occasion of considerable excitement and high expectation, as I have often experienced. Whenever a sheepshead is brought on board the boat, more joy is manifested than by the possession of any other kind of fish. The sportsmen view the exercises so much above common fishing, that the capture of the sheepshead is the most desirable combination of luck and skill; and the feats of hooking and landing him safely in the boat furnish abundant materials for the most pleasing and hyperbolical stories. The sheepshead is a very stout fish, and the hooks and line are strong in proportion; yet he frequently breaks them and makes his escape. Sheepshead have been caught with such fishing-tackle fastened to their jaws. When the line or hook gives way, the accident makes a serious impression on the company. As the possession of the sheepshead is a grand prize, so his escape is felt as a depressing loss." In Mitchill's time, also, we learn that the fish was sometimes captured by spearing in the night by torch-light, in the wide and shallow bays of Queens and Suffolk counties.

The sheepshead, we are told by Mr. S. E. Clarke, begins its labors of reproduction in March and April along the Florida shores. Before this period it had been

going in schools, but when they are ready to spawn they scatter. The spawning is generally effected at the mouths of rivers and inlets. "The eggs are deposited in shallow water near the shore, and are about the size of mustard seed, and dark. At the spawning season the fish play near the surface and become thin and unfit for food. The young fish are abundant in shallow water among the rocks." As the sheepshead is thin and almost unfit for food when it first appears on the northern coasts, it has been supposed that the spawning season had passed. This, however, requires to be confirmed.

There seems to be considerable difference in the size of the sheepshead, if we can credit various accounts. According to Professor Goode, in the south, sheepshead are usually small, rarely exceeding two pounds in weight; but about New York harbor they sometimes weigh from twelve to fifteen pounds, though the average size is not more than half this weight.

Other fishes related to the scup and sheepshead are the *Lagodon rhomboides*, which is best known in the south as pin-fish, and several species of the genus *Calamus* which are called porgee in the south.

Closely related to the Sparidæ, and sometimes referred to it, are certain fishes which may perhaps be best isolated under the name LUTJANIDÆ. These have much external resemblance to the Sparidæ, but there are teeth on the palate, and the jaw teeth are acute, and, what is of more importance, there are peculiarities in the skeleton, especially in the mode of articulation of the ribs, which at least stamp them as a definable and natural group, whatever may be the opinion as to its value. European naturalists have approximated the species to the Serranidæ, but they unquestionably have more points of agreement with the Sparidæ. The species are numerous in the tropical seas, and there are not less (and probably more) than twenty-seven species, representing eight genera, in the American seas.

The red-snapper of Florida (*Lutjanus vivanus* or *blackfordi*) is one of the most important and esteemed of southern fishes and has for some years been regularly sent from Florida to New York and other cities. The color, like that of other species of the family which inhabit waters of considerable depths, is a nearly uniform rose-red; the fins are of a brick-red; the anal fin is angulated by its produced median rays. It ranks among the large market fishes.

The special home of the red-snapper is on the banks and amidst the reefs of the Gulf of Mexico, and near or along the Florida coast, and northward to the Savannah Bank, but it is quite a traveler, and occasionally (although very rarely) individuals are caught northward even as far as Block Island. About the Florida reefs, and as far north as Tampa Bay, "where there are reefs and rocks, they live in holes and gullies where all kinds of marine animals and fish are most abundant," and numbers may sometimes be seen congregated "about a solitary ledge protruding over a level bottom of white sand." Such has been the experience of Mr. S. Stearns. They are associates in such places, sometimes of the groupers (*Epinephelus*) and sometimes of the southern sea-bass (*Centropristis*).

The red-snapper is a carnivorous and a voracious fish, and feeds largely on crabs and prawns, as well as fishes. The contents of their stomachs, indeed, have furnished a number of novelties to naturalists. The breeding season in Florida, according to Mr. Stearns, is in May, June, and July. The eggs are deposited in the bays and at sea.

A species of *Lutjanus* related to the red-snapper is the common gray mangrove or Pensacola snapper (*L. griseus* or *stearnsii*). The color generally is dark greenish

or grayish on back and sides, and reddish below, and in those inhabiting rather deep water the red suffuses the whole body; the soft dorsal, anal, and caudal are blackish tinged with vinous; the anal fin is rounded at its middle. It is said to be "an excellent food-fish, generally thought to be superior in flavor to the red-snapper." Occasionally it ascends on the coast as far as New Jersey.

A singular representative of this family occurs in the Pacific. It is the *Hiplopagrus guentheri*, and its interests lie in the fact that its anterior nostrils are at the edge of the snout, and the palatine bones are toothless, but several molar teeth exist on the head of the vomer. Yet in most other respects it resembles quite closely the gray-snappers. It is a very good food-fish.

A family with numerous and striking species, the SERRANIDÆ, now comes up for notice. These have the body compressed and generally oblong; the scales are moderate and mostly ctenoid; the head is conic, and the lower jaw projects more or less; teeth are on the palate as well as jaws, usually in large numbers, and in most species are interspersed large or canine teeth; the dorsal fin, as a rule, is entire and composed of an anterior spinous and a posterior soft portion; the spines are pungent and nine to twelve in number; the anal fin is short and armed with three spines. A few only of the numerous species, of which there are nearly 300, can be noticed.

The name-giving genus of the family (*Serranus*) is composed of comparatively few species, two of which are common and celebrated Mediterranean fishes, and others are confined to tropical waters. The two Mediterranean species are *S. cabrilla* and *S. scriba.*

Very nearly related to *Serranus* is *Centropristis*, containing several species found along the eastern American coast. These all have the tail trifurcate, the middle rays being about as much produced as the external.

The common sea-bass of the north, *Centropristis furvus*, is the best known species of the genus. It is also known as the black-fish. The body is of a dusky brown and blackish, more or less mottled with pale spots arranged in longitudinal stripes along the rows of scales. The body is robust and the fins large, the dorsal spines being simple and rigid. It is one of the most common fishes of northern waters and is especially found on banks in company with the porgee. It is, however, by no means confined to such places, but invades the estuaries and approaches the shores, seeking shelter and protection under loose stones and in cavities among the rocks. At the approach of cold weather it retires into water of greater depth and is supposed to remain there in a torpid or quiescent state till the increasing warmth develops its generative functions and desire for more food. It puts in its appearance in numbers along the Massachusetts coast some time in May, although stragglers may be caught still earlier. It is generally believed that its feeding time near shore "is during the lull of the waters between the turn of the tides, when they are easily taken by the angler." It is quite a voracious fish and not shy in taking the baited hook.

A very near relation of the northern sea-bass (*Centropristis atrarius*) replaces it along the southern coast.

The rock black-fish of the South, *Centropristis philadelphicus* is a much more slender fish than its congeners and gayer in color. The back is grayish, tinged with purple reflections, and the sides are crossed by six dusky gray bars, which are continued over the back; the head is brown, relieved by blue stripes on the sides, especially in front of the eyes, and the dorsal fin is tinted with olive, and blotched by a conspicuous irregular black spot near the middle; the dorsal spines are elongated, and filamentous

at the end. It is a rarer fish than its congeners, and is mostly confined to the southern Atlantic coast, rarely extending northward to New York.

The genus *Epinephelus* is one containing numerous species in the American seas and elsewhere; they are chiefly confined to the tropical and subtropical waters. The species agree in having the interorbital space narrow, the eyes subcentral, the scales of the lateral line simple, and the anal fin short, having only eight or nine rays. A few wanderers sometimes extend northwards and southwards considerably beyond their ordinary range. Such is the case with a couple of the American species.

Epinephelus morio, the red grouper, is brownish, marbled with ash, but reddish below; the soft parts of the dorsal and anal fins are margined with blue. It is a common fish in the south, and has long been a favorite market fish, being sent from Florida to New York and elsewhere; but occasionally, though very rarely, it wanders into the vicinity of New York itself. It is abundant in the Gulf of Mexico as well as along the Florida coast, and in those regions is found throughout the year. It is a voracious fish, and preys to a large extent upon crustaceans and fishes. Its movements, according to Mr. Stearns, are rather slow, and, when hooked, it is hauled up more like a dead weight than like a live fish. "When taken from the water, the grouper is remarkably tenacious of life, and will live several hours, even though exposed to considerable heat; this is one reason why the Key West fleet prefer groupers for transportation to Cuba, since they are obliged to go a long way to market, and through warm water, and no other fish of the kind would bear crowding and chafing in the wells of the smacks."

Although the red grouper is indeed a large fish compared to most, often weighing forty pounds, it is almost a pigmy compared with a related fish of this family, the jew-fish, guasa, or warsaw (*Promicrops itaira*). This fish is yellowish or olivaceous, sprinkled with numerous brown spots. It is the largest of the American Serranoid fishes, and indeed there are not much more than half a dozen true fishes that will compare with it in size. It has been said to reach the weight of seven hundred pounds, although this is at least very exceptional, but it frequently attains a weight of four hundred to five hundred pounds. Perhaps the most common popular name is jew-fish, but, besides the other names mentioned, it is sometimes called black grouper. It is apparently a common fish, and lives chiefly on the same spots as do snappers and common groupers. Its voracity is in proportion to its size, and when put in the well with other fish does great damage. The fishermen, therefore, generally sew up the mouth before placing it with others.

Another species of gigantic size, known also by the same name, jew-fish (*Stereolepis gigas*), inhabits the coast of southern and Lower California. It also reaches a weight of five hundred pounds, and it is chiefly found in moderately deep waters, where it is quite abundant, especially about the islands of the coast. It is often taken by swallowing a white-fish (the *Caulolatilus princeps*) when the latter is on the hook. "Its flesh is of excellent quality, and, when small enough to be available, always bring a very high price."

There is a small group of fishes confined to the tropical American waters, which is noteworthy on account of the combination of characters exhibited by them. In form and external appearance they closely resemble some of the Serranidæ, but the dorsal fin has only two or three spines, and the anal is entirely destitute of them. These characters compel us to distinguish the group as a family under the name RHYPTICIDÆ. The scales are smooth and covered with mucus, so as to give a very unctious feel to

the body; this peculiarity has obtained for them the name of soap-fish, by which they are generally known. One species of the family (*Rhypticus saponaceus*) is moderately abundant in the Caribbean Sea. Another species (*Rhypticus* or *Promicropterus bistrispinosus*) is an inhabitant of the southern Atlantic coast, and one or two others appear to occasionally wander to the borders of the United States.

There are some fishes, closely related to the Serranidæ, which have, however, a physiognomy of their own; there are two dorsal fins, the first composed of nine spines, the second with a spine and about twelve rays; the anal fin has three spines and nine to eleven rays. The skull and other parts of the skeleton seem to justify their family distinction and a special name — the Labracidæ or Roccidæ.

The *Labrax* or *Dicentrarchus lupus* of Europe is a fish with a long history and highly esteemed from ancient days. While it is most common in the Mediterranean, it is by no means rare farther north and along the British coasts. The general name bass (a corruption of the Dutch for perch) was early given to it in England, and that

Fig. 126. — *Roccus lineatus*, rock-fish, striped-bass.

name strictly belongs to it by virtue of long usage and restriction, although it has been subsequently applied by the English colonists to numerous other fishes, most of which have very little resemblance or affinity to the true bass.

Nearly related to the bass of England are two species, of which one occurs in the sea (running up, however, into fresh waters) and one is confined to the fresh waters of America; these constitute the genus *Roccus*. They have the operculum armed with small straight teeth below, and the tongue has true teeth in one entire or divided patch near the root, and lateral bands are found along the margin.

The striped-bass of New York, or the rock-fish of Philadelphia and Washington (*Roccus lineatus*), is an elongated fish, olivaceous-silvery, with seven or eight longitudinal blackish bands along the sides, one of which is coincident with the lateral line. It is one of the most abundant and most esteemed fishes of the northern waters. Its natural range is from the Gulf of St. Lawrence to Florida, although it extends occasionally both northward and southward of these bounds. In fact it is found in almost all waters whose temperature is not higher than 65° or 70°. On the other hand it is not very sensitive to cold, and there is evidence that, when detained throughout the winter in shallow places, it frequently enters into a state of torpidity.

As is indicated by one of the names, it affects especially the rocky shores of the

bays and sounds, where it seeks after food in the form of crabs, shrimps, squids, and small fishes. It also enters rivers and ascends for long distances, and is frequently found in perfectly fresh water. Besides the crustaceous food alluded to, the bass poaches upon clams and mussels, which it obtains by delving with the snout. Perhaps its predominant food, however, is furnished by members of its own class, for it is a highly carnivorous fish.

The spawning season appears to be in May from North Carolina to New Jersey, and June in New Brunswick. The eggs are very numerous; as many as 2,248,000 eggs have been estimated in a fish of large size. The growth is quite rapid.

The size sometimes reached is very large. Mr. Goode tells us that "the largest striped-bass on record was one weighing one hundred and twelve pounds, taken at Orleans, Mass., in the town cove. Such a fish would be at least six feet in length." "But in the Potomac, Hudson, and Connecticut rivers, the largest seldom exceed thirty or forty pounds, though in the Potomac fifty-pound fish are not unusual." The average size, however, does not exceed twenty pounds. Indeed, the average size must be much less than that.

Few fishes are superior to the striped-bass as a food fish, "its flesh being firm, finely flavored, and hard enough to bear exposure to the air for some time without injury. . . . Those in the markets are chiefly obtained in seines and traps, set at various points along the coast from the south side of Cape Cod to New Jersey."

A species related to the striped-bass occurs also exclusively in fresh water, and especially in the great lakes and the Mississippi basin. It scientific name is *Roccus chrysops*, and it is chiefly known as the white-bass, but not unfrequently by the same name as its salt-water relative, the striped-bass. It is more compressed and higher than the rock-fish, and the teeth of the base of the tongue are in a single patch. The color is silvery, shaded with yellowish below the lateral line, and along the sides are narrow blackish lines, four or five above the lateral line, one along the lateral line, and a variable number below. It is esteemed as a table fish as well as a game fish, although much inferior in both respects to the rock-fish.

Two other fishes related to the European and striped basses are also found in America. Both belong to the genus called *Morone*, which has the spines standing out at an angle from the lower margin of the operculum, as in the rock-fish (*Roccus*), but has no teeth on the base of the tongue, while it has bands on the sides.

The common white perch, *M. americana*, is olivaceous on the back, and silvery below, with very faint lighter stripes. It chiefly frequents brackish waters, and is most common about the mouths of rivers or other streams, but it also ascends into fresh-water streams to a considerable distance, and is found in perfectly fresh water, both running and in ponds. In ponds it seems to assume a somewhat darker hue than in the sea. It ranges from the British provinces southward into the Gulf of Mexico, although it is rare about southern Florida. In the north it is said to "hibernate in the deep waters of our bays, and ascend the fresh tidal rivers soon after the ice and snow water have run off."

Like its relative, the white perch is a greedy feeder, and affects "the spawn of other fish, particularly that of the shad;" it also feeds on "insects, crabs, minnows, and on the migratory schools of young eels which are found in the months of April and May in great numbers at any rapid or dam, obstructing the outward flow of the tide."

The spawning season of the white perch is May and June in the Middle and New

England states. After spawning, "they resort to deeper waters to recuperate, and all summer long are found by the angler swimming around the deep sunk pier or the timbers of the rickety old bridge, snapping at shrimps or chasing the minnows; at flood tide high up amongst the water lilies, and never refusing a bait if of the right sort and properly presented." The white-fish is a small fish compared with the rock-fish, with which it is often associated. Sometimes, however, it reaches a respectable size, and has been found over two pounds in weight.

The only other American form of this family is a curious species found in the southern part of the Mississippi valley, although it occasionally extends northward to Illinois. In shape and general appearance it is like the white perch, but has a brilliant brassy color, tinged with olivaceous above, and on the sides are seven to nine black longitudinal bands much larger than in any other species of the family; those below the lateral line are interrupted behind, so that the posterior part alternates with two of the preceding. To this feature, the scientific name, *M. interrupta*, refers. A

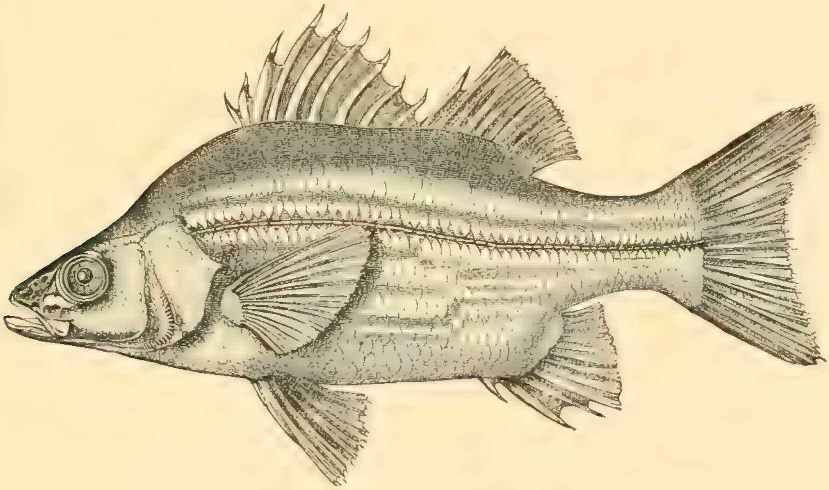


FIG. 127. — *Morone interrupta*, brass bass.

popular name is brass bass. It attains about the same size as the white perch, and is confined apparently to the fresh waters.

The common yellow perches of Europe and North America constitute a genus which is the type of the family PERCIDÆ. This family formerly included almost all of the preceding percoid types, and even by most European naturalists of to-day, the Centropomidæ, Pristipomidæ, Lutjanidæ, Labracidæ, Serranidæ, and Rhypticidæ, besides several others, are confounded in it. As limited by American ichthyologists, however, it is much restricted, although it still contains numerous species. These have the body rather elongate, and highest near the head, the scales rather small and ctenoid (rarely almost wanting), the lateral line concurrent with the back, the head variable but without a keel above, two dorsal fins, the first armed generally with a goodly number of spines (12 to 15) but sometimes with as few as six, and the anal with not more than two spines (sometimes only one). Finally, the vertebræ are more numerous than in the preceding families, ranging from thirty to forty-five. (There are forty in the yellow perches.)

The species of this family are all naturally confined to the fresh-water regions of the

northern temperate zone, and about eighty species are known. So far as size is concerned, there are two groups; one contains comparatively large species, of which there are only three in America and about ten in Europe and Asia; the other is represented by about seventy species exhibiting some remarkable variations, and is restricted to North America.

The common perches of Europe and America are very closely related, and constitute the genus *Perca*, which, by successive restrictions, has been reduced from an immense and unnatural assemblage to three species. The perches are moderately elongate and compressed fishes, with thirteen to fifteen spines in the first dorsal, which is entirely distinct from the second, the head without enlarged mucous cavities, and the teeth small. The common European perch is the *P. fluviatilis*; the American, *P. americana*.

The American yellow perch is an inhabitant of many of the streams and ponds of the eastern United States, especially to the northward. In appearance as well as

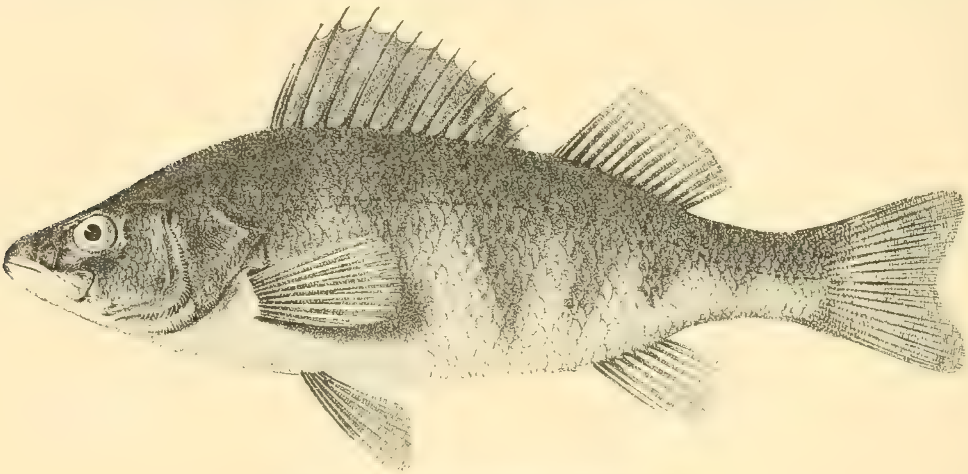


FIG. 128. — *Perca americana*, yellow perch.

habits, it is very like the European fish, but is held in much less esteem, both as a food and game fish, in America than in Europe.

The largest and best of the Percidæ are the pike-perches, comprised in the genus *Stizostedion* or *Lucioperca*. The body is more elongate and less compressed than in the yellow perches, the spines of the dorsal more numerous (17 to 23), the head broader but also without mucous cavities, and some of the teeth are much enlarged and canine-like. Pike-perch is rather a book than vernacular name, and the most common one is pike, qualified by some prefix, such as wall-eyed, yellow, blue, or gray. They are, however, neither like the true pike nor related to it, but on the contrary they are closely related to the true perches.

Wall-eyed pike, yellow-pike, blue-pike, salmon, jack-salmon, glass-eye, and dory are names in which the largest of the American pike-perches (*S. vitreum*) rejoices, in some one or other section of the United States. It is dark olive with indistinct oblique brassy lines; the first dorsal has a large black blotch behind, and the pectorals are dusky and plain, or without blotches. It attains a weight of ten to thirty pounds, and a length of nearly three feet. This species, which for brevity we call glass-eye, is one of the most important food-fishes of the lake region, and in some places ranks

as first, though generally it is below the white-fish, and in some places below the sturgeon. It varies in numbers at the different fishing stations on the lakes. We have been told that "Saginaw bay produces more fish yearly than any equal extent of inland water in the United States," and the glass-eye, or yellow-pike as it is called there, is notable for its abundance and excellence; it is "*the* most abundant and important fish in Saginaw bay."

The species, as is indicated by its teeth, is a highly rapacious fish, and resembles the pike in its predatory habits and armature for warfare on the rest of creation if in no other way. Fishes of almost all kinds fall victims to it. It is also "considered destructive to young fish and spawn." The spawning season commences from early in spring to April or even May, according to latitude and temperature.

As already indicated, the most extensive fishery is in Saginaw bay. There, fishes are taken both by pounds and gill nets, in spring and early summer, and again towards the end of summer and later. In winter they are obtained by spearing them through the ice; in spearing them, "a decoy fish is used to lure them within reach." The markets receive the fish fresh and salted; when shipped fresh, they are not dressed at all; in spring they are, to some extent, salted and sold as 'salt pickerel.'

Sauger, sand-pike, gray-pike, blue-pike, and horn-fish, are the chief designations of a smaller pike-perch, the *Stizostedion canadense.* The body is more uniformly slender, and rounder than that of the glass-eye; the color is olive gray above, with yellowish sides and dark mottling; the first dorsal has two or three rows of round black spots, but no posterior blotch; and the pectorals have a large black blotch at the base. Its average weight is about a pound, but some run upwards till a maximum of about fifteen pounds is reached. It is much less esteemed than its relative.

FIG. 129.—*Microperca punctulata.*

The rest of the American Percidæ are of very small size, and known under the scientific name Etheostominæ, and the quasi-popular one of darters. They are among the smallest of fishes, and one (*Microperca punctulata*) is one of half a dozen of the smallest of known fishes, "barely attaining the length of an inch and a half," while the giant of the group is only eight inches long and very slender. They are by far the most numerous of the family, about seventy species being known, all confined to North America. They are regarded as dwarfed descendants of perch-like ancestors, which have found protection and place by reason of their diminished size — the "mountaineers of fishes." In the words of Professor Forbes, "forced from the populous valleys of the river beds and lake bottoms, they have taken refuge from their enemies in the rocky highlands, where the free waters play in ceaseless torrents, and there they have wrested from stubborn nature a meagre living." But they have also descended into the streams of the plains; mostly, they prefer clear running water. They "lie on the bottom, concealed under stones, darting, when frightened or hungry, with great velocity, for a short distance, by a powerful movement of the fan-shaped pectorals, then stopping as suddenly; they rarely use the caudal fin. When at rest they support themselves on their expanded ventrals and anal fin." This, Professors Jordan and Gilbert, to whom we are indebted for much of our knowledge of these lowly forms, tell us.

By far the largest of all the darters is the *Percina caprodes.* This is almost the only one that has received vernacular names. It is variously known as the log-perch, hog-fish, and rock-fish. It is more like a perch than any of the other species, and is the only one large enough to take a hook, but it is valueless.

We can only pause to mention several species which may give an idea of the range of variation in the family.

The *Etheostoma lineolata*, or striped darter, is a typical form of the group; as the name indicates, it has lines of color along the longitudinal rows of scales. It has been said to be "one of the most singular and handsome of the darters." It inhabits the streams of the west, from Indiana to Minnesota.

The *Microperca punctulata*, or least-darter, is noteworthy as being the smallest species of this group of small fishes. It abounds in the clear streams of the northwestern States, and only grows to a length of an inch and a half.

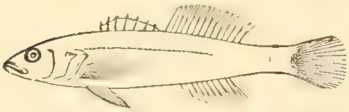


FIG. 130. — *Etheostoma lineolata*, striped darter.

The *Ammocrypta pellucida*, or sand-darter, is an Ohio valley fish. It and its immediate relatives differ from most of the family in preferring "a sandy bottom, where, by a sudden plunge, the fish buries itself in the sand and remains quiescent for hours at a time, with only its eyes and snout visible."

Another family of special interest to the American naturalist is known as CENTRARCHIDÆ. It is to this that the species called sun-fish, rock-bass, and black-bass belong. They are all inhabitants of the fresh water, and most of them have a peculiar form by which they may be readily distinguished from at least all other American fresh-water fishes. The body is compressed and oval, balanced so that there is no greater projection upwards than downwards, except perhaps at the front of the back. The lateral line is continuous and concurrent with the back. The head is of moderate size; the nostrils are normally double; the cheeks and opercula are scaly; and the operculum generally ends in a rounded flap, but sometimes, though rarely, in a spinous one, as in the black-bass; in any case there is a black spot on the posterior extension of the operculum, and the extension is often such as to remind one of an ear; often the black is bordered by red or yellow, and then it presents a very striking appearance. The dorsal fin is long, and generally there are ten spines and ten rays; rarely, as in the black bass, there are twelve or thirteen rays, and in one type the spines are reduced to six or eight. The anal fin is just opposite and like the soft part of the dorsal fin, or, sometimes, obliquely placed and nearly as large as the entire dorsal fin. There are some interesting features in their habits. All the species consort together in pairs during the breeding season, and are very domestic; they clean a circular spot of ground near the shore, where the female lays her eggs, and male and female guard this nest with care, and courageously drive off intruders. Nearly fifty species of the family are known, which are distributed among ten genera.

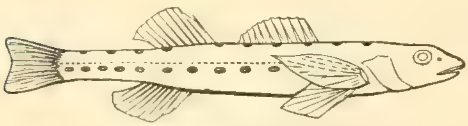


FIG. 131. — *Ammocrypta pellucida*, sand-darter.

The black-basses are the least specialized type of the family, and represent the genus called by American ichthyologists *Micropterus*, and by Europeans — at least formerly — *Grystes* and *Huro*. This genus is distinguished by the comparatively elongate form of the body, the low dorsal, and especially the slight development of the spines, which decrease to the soft portion, leaving a considerable emargination between the bulk of the spinous and the soft portions. The operculum has a spiniform projection; the mouth is large, and the caudal emarginated. Two species of this genus are generally recognized, the large-mouthed black-bass (*M. salmoides*) and the small-mouthed species (*M. dolomieu*). These resemble each other very much, and

the habits are the same, but they may be readily distinguished by attention to a few characters, and these few are co-ordinated with a number of others.

The large-mouthed black-bass (*M. salmoides*) has the mouth deeply cleft, so that the maxillary of the adult extends back of the orbit; the scales are quite large, there being sixty-five to seventy in the lateral line, and the number of rows between the lateral line and the back is only seven or eight. The distribution of this form is very wide, and it extends from the British provinces southward in one direction to Florida, and in another direction into Mexico. The small-mouthed black-bass (*M. dolomieu*) has the mouth comparatively small, and the maxillary of the adult does not extend beyond the orbit; the scales are considerably smaller, there being seventy-two to seventy-five along the lateral line, and as many as ten or twelve rows between the lateral line and back. It does not extend north of the region of the great lakes, and is not known to reach farther south than South Carolina and Arkansas. In most places it is associated with the large-mouthed species. It does not, as a rule, reach as large a size as its relative.

The black-basses, like the other members of the family, prepare nests and take

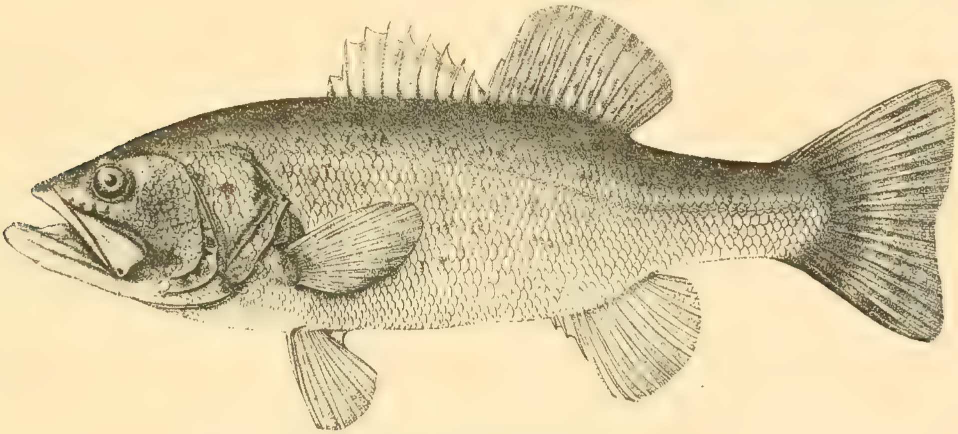


FIG. 132. - *Micropterus salmoides*, large-mouthed black-bass.

zealous care of the eggs and young. The sexes begin to pair about the commencement of hot weather. They then select suitable spots for their nests, "usually upon a gravelly or sandy bottom, or on rocky ledges, in water from eighteen inches to three feet in depth in rivers, and from three to six feet deep in lakes and ponds; and, if possible, adjacent to deep water, or patches of aquatic plants, to which the parent fish retire if disturbed. The nests are circular, saucer-like depressions, varying from one to three feet" in diameter, or about twice the length of the fish. They are "formed by the bass, by fanning and scouring from the pebbles all sand, silt, and vegetable debris, by means of their tails and fins, and by removing larger obstacles with their mouths. This gives to the beds a bright, clean, and white appearance, which in clear water can be seen at the distance of several score yards." When the nests are thus prepared, the females deposit their eggs on the bottom, "usually in rows, which are fecundated by the male, and become glued to the pebbles or sticks contained therein. The eggs are hatched in from one to two weeks, depending on the temperature of the water, but usually in from eight to ten days."

During the period of maturation, "the nests are carefully guarded by the parent

fish, who remain over them, and, by a constant motion of the fins, create a current which keeps the eggs free from all sediment and debris. After the eggs are hatched, and while the young remain on the nests, the vigilance of the parent fish becomes increased and unceasing, and all suspicious and predatory intruders are driven away." After escaping from the egg, "the young fry remain over the bed from two to seven days," after which they "retire into deep water, or take refuge in the weeds, or under stones, logs, and other hiding-places."

The growth of the bass depends upon the warmth of the water and the quantity of food; when the latter is plentiful they grow very rapidly. They attain maturity in about three years. The maximum size varies for the two species. The large-mouthed black-bass occasionally reaches a weight of about fourteen pounds, but in the north six to eight pounds are the largest that would be likely to be found. The small-mouthed bass never reaches so large a size, and, indeed, is not found in the regions where the large-mouthed species attains its greatest size. "The maximum weight of the small-mouthed form of the north and west may be said to be four or five pounds."

Both species of black-bass are ravenous feeders, and attack almost all kinds of fish,

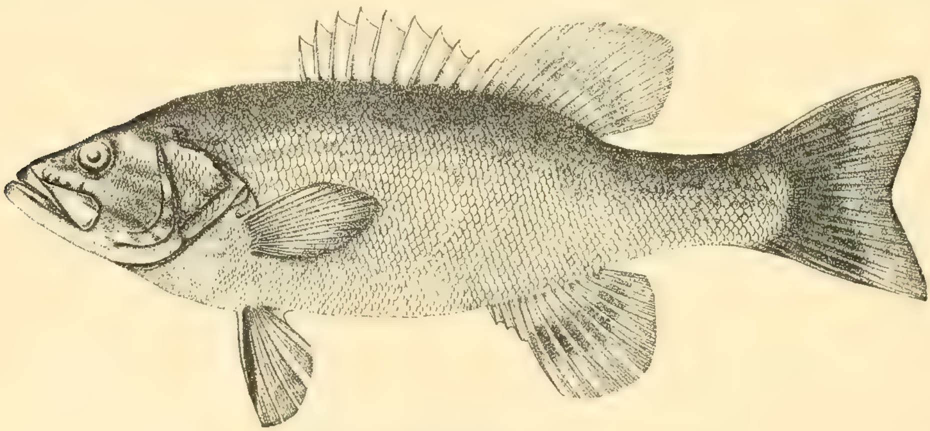


FIG. 133. — *Micropterus dolomieu*, small-mouthed black-bass.

and those nearly their own size are not exempt from danger. They are even a formidable enemy of the pike, and when a bass and pike of equal size are pitted against each other, the chances are in favor of the bass. These fishes, therefore, are not suitable for introduction into small ponds, as they would soon depopulate the water.

It is asserted that in the north the "black-bass undoubtedly hibernate," and, according to Dr Henshall, "it has been proved, in numerous instances, that they bury themselves in the mud, in the crevices of rocks, under masses of weeds, or sunken logs, in the deepest water, and remain dormant until spring." In the south hibernation is not effected, and they may be caught throughout the year.

The black-basses are among the finest game fish in America, and are peculiar to the continent. So highly, indeed, are they esteemed for their game qualities, that a well-known English sporting writer, Parker Gillimore, considered one of them to be the superior of the trout, "for he is equally good as an article of food, and much stronger and more untiring in his efforts to escape when hooked." An excellent volume has been devoted to a description of its gaminess, by Dr. Henshall, in his "Book of the Black-Bass," from which our figures are taken. Dr. Henshall informs us that "the

black-bass is eminently an American fish, and has been said to be representative in his characteristics. He has the faculty of asserting himself and making himself completely at home wherever placed. He is plucky, game, brave, and unyielding to the last, when hooked. He has the arrowy rush and vigor of the trout, the untiring strength and bold leap of the salmon, while he has a system of fighting tactics peculiarly his own. He will rise to the artificial fly as readily as the salmon or the brook trout, under the same conditions, and will take the live minnow or other live bait under any and all circumstances favorable to the taking of any other fish." Finally, Dr. Henshall considers him, "inch for inch and pound for pound, the gamest fish that swims. The royal salmon and the lordly trout must yield the palm to a black-bass of equal weight." That he will eventually become "the leading game fish of America" is Dr. Henshall's oft-expressed opinion and firm belief.

It need scarcely be added that the sportsmanlike way of obtaining the black-bass is by the fly, but they are often caught by trolling, and indeed, being such bold and eager feeders, they may be caught in almost any of the ways which anglers are wont to use for catching other fresh-water fishes.

Whilst the black-basses are unequalled in their family as game fishes, there are several others that give sport — and a good deal of sport — to the boy anglers, although at a great distance behind the black-bass. A species called rock-bass (*Ambloplites rupestris*) has somewhat the external aspect of the black-bass, but its dorsal and anal fins are much more developed, the body shorter and deeper, and the pterygoids are armed with villiform teeth. The rock-bass is common from the region of the Great Lakes southward to Louisiana and west of the Alleghanies. It is a bold biter, and is of some value both as a food and game fish. Only a single species of this family occurs on the Pacific slope, the *Archoplites interruptus*. It is much like the rock-bass just described, but has seven branchiostegal rays, which no other member of the family, except sometimes the black-bass, shows. It attains a considerable size, frequently being found a foot long, or even more. It is confined to the Sacramento and San Joaquin rivers, and in them is abundant.

Passing over other species, we reach the sun-fishes, or pumpkin-seeds. These form a group very striking on account of the distribution of colors, and the strong contrasts afforded by the contiguous colors. The operculum is always produced into a large rounded or ear-like lobe, which is quite black, sometimes through its whole extent, but often there is a border of lighter (blue, red, or yellow) behind. A number of species of this type are found in the Mississippi valley, but in the fresh waters of the eastern states only two or three species occur.

The most common sun-fish of the New England and middle states is a species (*Lepomis gibbosus*) distinguished by the rather short opercular lobe, whose border behind is decorated with scarlet in its upper part, and yellow in the lower part. The body is greenish-olive, more or less shaded with bluish, and variegated with spots and blotches of orange, while the belly is of a bright orange color; the cheeks are brownish orange, and marked with several wavy-blue streaks. There is no handsomer fish in the American streams. There is also no fish better known to the boys, and none more attractive in its habits than this. In the summer it may be seen in pairs near the banks of ponds, and such are guarding their eggs or young. It is almost exclusively angled for with earth-worms.

A species nearly equally common, and in some places more common, although less universally distributed in the east than the species just mentioned, is one that has

been called the long-eared sun-fish (*Lepomis auritus*). The body is more oblong than the common sun-fish, but what distinguishes it especially is the elongation of the opercular lobes, which extend far backwards, and are of a jet black color. The body itself is olive on the back and sides, but the belly is a brilliant orange-red. It reaches a length of about eight inches.

Still another species (*L. pallidus*), known as the blue sun-fish, or copper-nose bream, and, rarely, dollardee, is common in the lake region and some of the western streams of New York, and thence it extends almost all through sections of the Union west into the Mississippi valley. It is indeed one of the most widely-dispersed of the family, and, where it occurs, one of the most abundant. It is, however, found in very few streams in the New England states. The body is much like that of the common sun-fish, being short and deep, but the opercular flap is about as long as wide, and without any brighter colored edge. It attains a length of about eight inches, and sometimes more.

Two smaller species of the family deserve notice, being remarkable for form and colors; both, unlike most others of the family, have the caudal fin convex behind.

The *Enneacanthus obesus* is distinguished by having nine dorsal spines, and by its dark cross-bands. It is rarely more than three inches long. Its favorite haunts are sluggish streams not far from the coast and amongst water plants.

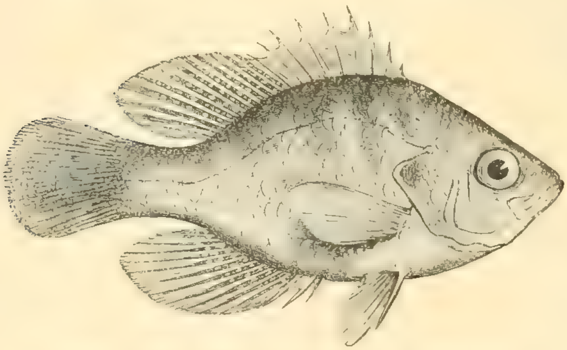


FIG. 134. — *Enneacanthus guttatus*, bream, pumpkin-seed.

The *Mesogonistius chætodon*, like most of the family, has ten dorsal spines, but is peculiar in the extension of these, at or toward the middle, into an angle, as the generic name indicates. Its color is very striking, as the illustration shows, and has suggested the gay colors of the tropical Chætodonts. It resorts to nearly the same places as the *Enneacanthus*.

The last of the family that require notice are two species which are distinguished by the strongly-compressed body, the concave and projecting snout, and especially the structure of the dorsal and anal fins. These are nearly equal in size, and are obliquely opposed to each other, the anal reaching further back than the dorsal; the dorsal fin has six to eight spines, and about fifteen rays, and the anal six spines and seventeen or eighteen rays. This character of the small number of spines, and consequently the abbreviation of the spinous portion of the dorsal fin, is unique in the family. The color is olive, mottled with dark green, but assuming a more or less brass-like hue, while dark marks or spots are scattered over the body; the operculum, which is pointed, has a dusky spot, but much less distinct than in the other representatives of the family. Such are some of the characteristics of the genus *Pomoxys*. Two species of the genus are known.

The *P. sparoides* is comparatively high, and has seven or eight dorsal spines. It is known under the names of calico-bass, grass-bass, strawberry-bass, and bar-fish, and is a common species in the great lakes and the upper Mississippi valley, as well as the

southern Atlantic States to Florida. It reaches a length of twelve inches, and is prized as a food fish.

The *P. annularis* has a more elongate body than its relative, and only six dorsal spines. It is known as the crappie, new-light, Campbellite, and bachelor, and is an abundant fish in the Mississippi river, especially southward. Like its congener it is regarded as an excellent table fish. The names new-light and Campbellite are due to the fact that it became abundant and the subject of observation when the religious denomination bearing those names originated.

There are some other families which belong to the series of Percoideous fishes, such as the Mænidæ, Ambassidæ or Bogodidæ, Pimelepteridæ, and Chilodipteridæ or Apogonidæ, but they do not demand special notice here. We therefore hasten to another series generally known as the Pharyngognathi.

The distinctive feature of the PHARYNGOGNATHI is that the lower pharyngeal bones, which are just behind the gill-arches, are consolidated together, instead of being

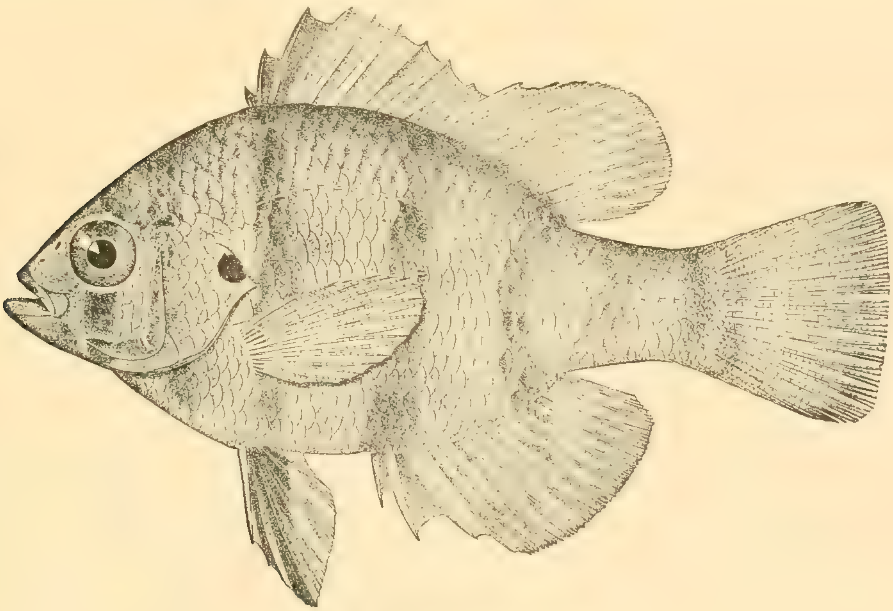


Fig. 135. — *Mesogonistius chætodon.*

separate as in most fishes. For this reason, and this only, European writers, following the great Müller, have generally isolated them as a peculiar order, but there does not appear to be any warrant for such a step, and two of the fishes which have been noticed a few pages back — the drum-fishes, of the family of Sciænidæ — have the corresponding bones as much consolidated as a large portion of the Pharyngognathi and yet, on account of their likeness to the other Sciænidæ, no one has ventured to remove them, even from the same family. It is to be understood, then, that the Pharyngognathi form a merely conventional and artificial group.

The first of these pharyngognathous fishes which we shall consider form the family Cichlidæ, or, as they are generally called, Chromididæ. Many of these look as well as act much like sun-fishes. The body is oblong, rarely elongated; the scales are rather large; the lateral line generally becomes interrupted, the head is diversi-

form, and the nostrils single; the dorsal is armed with numerous spines, and the anal is also often possessed of many spines, never with less than three. The species are numerous, and naturally confined to the fresh waters of tropical and sub-tropical America and Africa, although the species of two genera have broken their African bonds, and extended and developed in the neighboring portion of Asia.

The Cichlidæ are interesting on account of their range of variation, their various peculiarities of structure, and their habits. Probably all take care of their young, and some have a very peculiar way of doing so. The male parent takes the newly laid eggs in his mouth, and there they mature and hatch. Species of three genera, two African (*Tilapia* and *Hemichromis*) and one American (*Geophagus*), exercise this peculiar mode of incubation or oral gestation.

Africa is the headquarters of the genus *Tilapia*, (formerly called *Chromis*), that has been considered to be the type of the family Chromididæ or Cichlidæ, but the genus has become extended into contiguous portions of Asia and is represented by not less than seven species in Palestine. The species have an oblong body and in aspect considerably resemble a sunfish; the teeth are in several rows, compressed and lobate, and much larger in the outermost row; the dorsal fin has fourteen to eighteen spines, the anal only three. The celebrated bolti of the Nile (*T. nilotica*) belongs to the genus and is also found in Palestine, in Lake Tiberias, and in this same lake is found another species (*T. simonis*) dedicated to the apostle Simon or Peter. If we must get hold of that fish out of whose mouth the apostle got the tribute-money, (and the task has often been attempted) this is as good a one to identify with it as any. If it lacks a spot behind the shoulders, many species of the family have one. At any rate, the species is peculiar to the Jordan system, and, as far as known, is restricted to lakes Tiberias and Huleh.

Dr. Lortet has given us some interesting observations on the propagation of *T. simonis*, which are worthy of being transcribed.

"The spawn is of the size of No. 4 shot, of a rich deep green. The female deposits about two hundred eggs in a little excavation which she works out among the rushes and roots. When she has completed her labor, she appears exhausted, and remains motionless at a little distance. The male, on the contrary, appears much agitated, turns himself about the spawn, swimming constantly above them, and probably fecundates them at this moment. In a few minutes afterwards he takes the ova one after another into his mouth, and keeps them in the buccal cavity against his cheeks, which then appear swollen in an extraordinary manner. Some of them, however, escape through his gills. The ova, though they are not attached by any membrane, nor by any glutinous matter whatever, remain very securely in his mouth, and are never dropped while he is in the water. It is only when he is thrown out on the sand that, in the struggle of his death-agony, they fall out, many however, remaining even then in his mouth.

"In this novel hatching-oven, the eggs, during several days, undergo all their metamorphoses. The little ones rapidly increase in size, and appear to be much incommoded in their narrow prison. They remain in great numbers, pressed one against another, like the grains of a ripe pomegranate. The mouth of the father-nurse now becomes so distended by his progeny, that his jaws cannot meet. The cheeks are swollen, and the animal presents the strangest appearance. Some of the young, arrived at their perfect state, continue to live and develop among the folds of the branchiæ. Others have their heads turned towards the mouth of the parent, and do

not quit the sheltering cavity till they are about four inches long, and sufficiently active and nimble to escape their numerous enemies."

Another species of *Tilapia* (*T. tiberiadis*), abundant in the lake or "sea of Galilee," is worthy of mention for its bearing on the miraculous draught of fishes recorded in the Scriptures. The notes on the abundance of the species by Canon Tristram are well worthy of reproduction.

"This fish, peculiar to the Jordan and its affluents alone, is found in the most amazing numbers from the lake Huleh to the head of the Dead Sea. It is by far the most abundant of all the species in the lakes. I have seen them in shoals of over an acre in extent, so closely packed that it seemed impossible for them to move, and with their dorsal fins above the water, giving at a distance the appearance of a tremendous shower pattering on one spot of the surface of the glassy lake. They are taken both in boats and from the shore by nets run deftly round, and enclosing what one may call a solid mass at one swoop, and very often the net breaks. They are also taken in large quantities by poisoned crumbs thrown from the shore on to the surface of the water. By casting-nets hundreds are often taken at once.

"This species especially is carried down at the mouth of the Jordan by thousands into the Dead Sea. The fishes never get further than a few yards, when they become stupefied, and soon turn over on to their backs, while cormorants and kingfishers, perched on the snags or floating logs, gorge themselves without effort, and often heaps of putrifying carcasses washed on the shore poison the atmosphere, and afford a plenteous feast to the ravens and vultures."

One species of the family enters into the southwestern portion of the Union. It belongs to the genus *Heros*, which likewise resembles a sun-fish superficially; the teeth are conical and in a band on both jaws; the dorsal fin has fifteen to eighteen spines, and the anal five to nine. This genus has about forty species, and is the predominant one of the family in the rivers and lakes of tropical America. The only one, however, that occurs within the limits of the United States is *Heros cyanoguttatus*; it lives in the fresh waters of Texas.

Closely related to the Cichlidæ, but inhabitants of the salt water, are numerous tropical fishes, constituting a peculiar family — the Pomacentridæ. Most of them are decorated with brilliant colors, and are of small size, rarely exceeding a few inches in length. One of the largest as well as northernmost of the family is a species occurring along the southern Californian coast, and known as the gold-fish, red-perch, and Garibaldi — the *Hypsypops rubicundus*. When adult it is of a nearly uniform deep crimson or orange. It often becomes a foot long, and attains a weight of about three pounds. It is, however, of little value, as it is not esteemed for the table.

The most important and widely dispersed of the Pharyngognathous families is the Labridæ. These are mostly of an oblong form, with the scales smooth and generally large, and often long and pointed on the tail, but in the northern forms they are small; the lateral line is generally interrupted, or abruptly bent behind; the head varies; the nostrils are double; the teeth conic, or rarely compressed, and not imbricated; the dorsal is single, with a long spinous and shorter soft portion; the anal has three or (rarely) more spines. The upper pharyngeal bones are distinct. The species are very numerous, nearly four hundred having been described. They are most abundant and diversified in the Indo-Pacific seas, and are very prominent there by their diversity and often singularity of form and gay colors. The northern species are distinguished by their small scales and the increased number of dorsal spines, as well as of vertebræ.

Of the Labrinæ two genera occur in the European seas, and two along the northern coast of the United States.

The wrasses of Europe constitute the genus *Labrus*, which has given name to the family.

The tautog or black-fish is the only known representative of a peculiar genus — *Tautoga* or *Hiatula* — and has been known longer than most of the American fishes; it is named *T. onitis*. Its teeth are in two rows, the gill-covers naked, and the preopercle entire along its edge; when old it is blackish, but diversified with lighter shades. The tautog reaches a tolerably large size, sometimes as much as twelve to fifteen pounds; but such a weight is quite exceptional.

The range of the tautog is from Maine to South Carolina. It is a lover of rocky shores, and water of about the depth of six to eight fathoms, but of course is not confined within such limits. It puts in an appearance on the coast at the commencement of moderately warm weather, and retires with its termination into deeper waters. It

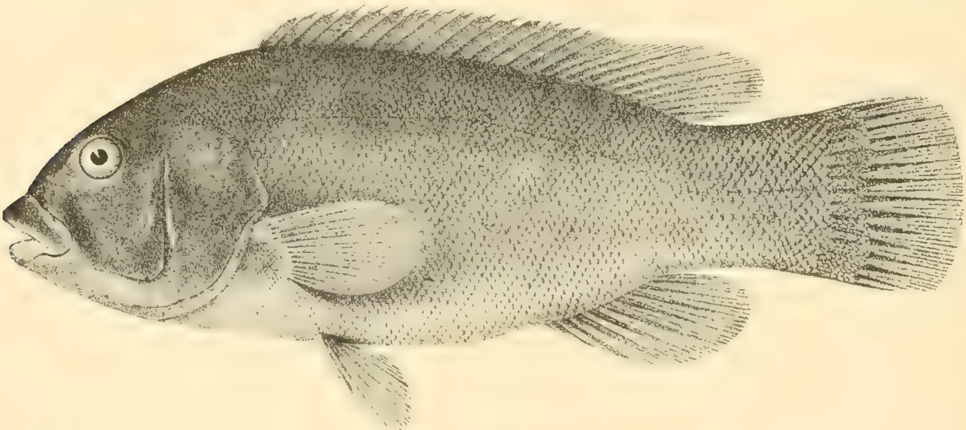


FIG. 136. — *Tautoga onitis*, tautog.

is quite sensitive to cold, and is said to hibernate; the belief is general among well-informed fishermen that the vent also closes for the cold season.

The flesh of the tautog is excellent, being "white, dry, and of a delicate flavor." The tautog is caught mainly in pounds and weirs, but also to a large extent by hook and line; its capture for the eastern markets, according to Mr. Goode, is "chiefly accomplished by the line fishermen of southern Massachusetts and Rhode Island, and the weir fishermen of the same district," but "no one fishes for tautog alone." But Mr. Goode adds that "at least two hundred fishermen are entirely or partly engaged in this business between Cape Cod and New York."

The catch in Narragansett Bay averages about six thousand pounds to each man for the entire season. Further westward, at Noank, Conn., there is a special late fishery, which lasts from the middle of October to early in December; about twenty-five men are engaged in it, who take each about one thousand pounds.

As an angle fish, also, the tautog is esteemed, but it cannot be truly called a game fish. Along shelving coasts it is sought for in "a boat anchored among the reefs or near wrecked vessels;" but, says Mr. Goode, "angling for tautog from rocks is a favorite pursuit of amateur fishermen all along the coast, particularly about New York, where there are precipitous shores, the angler standing upon the rocks."

An equally well known but far less valuable fish than the tautog is the species variously called burgall, cunner, chogset, blue-fish, blue-perch, sea-perch, and nipper, — the *Ctenolabrus adspersus* of most ichthyologists. Its teeth are numerous, and in a moderately broad band; the gill-covers are scaly, and the preopercle has a finely serrate margin. The color varies, but it is mostly brownish-blue more or less suffused with yellowish. It is to be ranged among the rather small fishes, for one of two pounds is almost unknown, and the largest that Mr. Goode had seen was a female ten and a half inches long, and weighing twelve ounces. Its habits are not unlike those of its large relative, the tautog.

Several other Labridæ occur along the southern and Pacific coasts, but they are outliers of tropical forms.

There are certain fishes found throughout the tropical seas, and generally known to English-speaking peoples as parrot-fishes. A species of this group has an exceptional range, being found quite abundantly in the Mediterranean Sea, and it was the most esteemed fish of the ancients, — Greeks as well as Romans, — by whom it was called *Scarus*. This name, taken for a "genus" of ichthyology, has given name — SCARIDÆ — to a family. The species are unusually uniform in their characters. All have the body oblong, the scales large, and in about twenty-four cross rows, the lateral line interrupted, the head compressed and subovate, nostrils double, the jaw-bones prominent, naked, and overlaid, more or less, with imbricate teeth, the dorsal with ten spines and nine rays, and the anal with two spines and nine rays. The upper pharyngeal bones have been said to be consolidated into a single piece, but they are really separate, although the teeth of the two interlock and would naturally give the impression that the bones were double; they have a sliding articulation with the approximated branchihyals. Over one hundred species are known, and the favorite haunts of most are the coral banks and groves of the tropics. On these they browse, and their colors are gay and accommodated to their surroundings. The species generally attain a considerable size.

The Scarus of the ancients, known as Scaro to the modern Greeks, *Scarus* or *Sparisoma scarus*, is the most northern species of its family. Its diet is correspondingly modified, for it feeds chiefly on *Fucus*, which it finely comminutes before passing it into the stomach. It was a fish which poetic enthusiasm proclaimed to be such a delicacy that the gods themselves were unwilling to reject even the excrements. Its flesh is said to be "tender, agreeable, sweet, easy of digestion, and quickly assimilated." It was also the first fish, so far as written records, go which piscicultural art diffused. We are told by Pliny that, in the reign of the Emperor Claudius, a Roman named Optatus Elipertius had a lot of living fish brought from the Troad and released in the Italian sea. There for five years they were protected, and when any were caught in nets or otherwise they were delivered again to the sea. The result of such endeavor and care was a subsequent abundance of the species about the region and an enlarged range.

Several species of Scaridæ occur along the coast of Florida.

Two other families belong to the same group or superfamily, Labroidea, as the Labridæ and Scaridæ, but only their names — ODACIDÆ and SIPHONOGNATHIDÆ — need be mentioned here.

In the waters of California are found fishes of the ordinary form, but remarkable for their viviparity, known scientifically as the HOLCONOTIDÆ or EMBIOTOCIDÆ. The body is compressed, and generally oval, more or less resembling that of the white

perch or sun-fishes; the scales are cycloid, of moderate size, and the lateral line is continuous and parallel with the back; the head is rather short and small, and the mouth is also small; the teeth are generally conical, but in some forms compressed or blunt; the dorsal fin is single, and armed with from eight to eighteen spines, and the whole folds into a groove on the back; the anal fin is elongated, and has three moderate or small spines. The Pacific waters of the United States are the great headquarters of the fishes of this family, but a couple of species have also been found in Japan; and indeed the Japanese species was the first described of the family; its viviparity, however, was not known until long afterwards. California had been for some years in possession of the Americans before any of these fishes were made known. In 1854, for the first time, several species of the family were sent to Prof. Agassiz, and described by him. The wonder excited at that time by the viviparity of fishes of such a form was great, and was bruited far and wide in the periodicals of that day. There are now known about twenty species of the family, referable to about a dozen genera. The species unhappily have no characteristic names of their own, but the Anglo-American settlers of the California coast gave to them some derived from the east, or still earlier from England, all belonging originally to fishes having no relation whatever to the viviparous species of California, and having but a very superficial likeness even. Perch and porgee are the terms most current; the former being given to the smaller species of the family, and the latter to the larger species; but on some parts of the coast, and especially about Monterey, surf-fish is in common use, and inasmuch as this is not preoccupied, it would be the best for adoption, and has been accepted by Professor Goode, who calls the Embiotocidæ "the surf-fish family."

The surf-fishes are mostly of small or medium size. The largest of the family, *Rhacochilus toxotes*, attains a length of only about eighteen inches, and a weight of about five pounds. The smallest species is the *Abeona minima*, which scarcely ever exceeds a length of four or five inches. All of the species are viviparous, and the ovaries are peculiarly modified in accordance with this feature. From ten to twenty is the number of young. The concourse of the sexes probably takes place in the fall, and it is said that the male and female come together with the ventral surfaces pressed against each other, and the heads of the sexes in opposite directions. In January the pregnant females have well-grown young, generally about half the size of the new born, and even at this time the young readily slip from the ovary, and the fish-stalls in the markets are apt to be littered with the fœtal fish expelled from their mothers.

The surf-fishes are not much esteemed as food, the flesh being watery, flavorless, and much inferior to the other prominent fishes of the Californian markets. Only their abundance and consequent cheapness commend them to many, but great quantities are consumed by the Chinese.

The largest of the surf-fishes (*Rhacochilus toxotes*), called alfiona at Coquel, sprat at Santa Cruz, and elsewhere simply perch, has the scales rather numerous, the teeth in a single row in each jaw, the lower lip free all around, and its free fold thickened and slashed or cut behind. It is in allusion to this slashing of the lips that the name *Rhacochilus* has been given. "It ranges from San Pedro to Cape Mendocino, and is generally common, although not nearly so abundant as some of the others. As a food fish it is considered the best of this very indifferent group."

Porgee is the name given to a moderately large member of the family (*Damalichthys vacca*) in Oregon and Washington Territory, while in California it is known as

the perch, or white perch. The scales are in this species also rather small, and the teeth uniserial in each jaw, but it is distinguished from all the other members of the family by the peculiar lower pharyngeal bones, that is the bones immediately behind the gill arches; these are very large, behind convex, and sloping downwards, with the anterior teeth truncated and tessellated, and the posterior flattened, imbricated, and pressed forwards. The species attains a weight of about two and a half or three pounds. It ranks as second to the alfiona as a food fish.

Two other species, congeneric with the Japanese fish, are known as the black surf-fish, and reach a weight of from two to two and a half pounds. One of these, *Ditrema lateralis*, is "an important food fish, although not of very good quality;" while the other, *D. jacksoni*, is probably brought into San Francisco market "in greater numbers than any other species," although it is "an indifferent food fish."

Perhaps the most abundant of all the surf-fishes is the little *Cymatogaster aggregatus*, which is generally known as shiner, but on Puget Sound is called minny, and by the Italians of California, sparada or sparad. All the preceding species feed upon crustaceans, or such small fishes as they can take, but there is one species peculiar in its diet. The *Abeona aurora* is distinguished by a peculiarity in dentition concomitant with a peculiarity in food. It is said to feed upon sea plants or algæ. It reaches a weight of about a quarter of a pound.

The surf-fishes are all inhabitants of the sea, save one species, which is confined to fresh water. The *Hysterocarpus traski*, which is known as the river perch, is a species distinguished by the great extent of the spinous portion of the dorsal fin, which is longer than the soft, and composed of sixteen to eighteen spines. The scales are large, and the teeth conical and uniserial. It reaches a weight of about half a pound. It is only found in the Sacramento and San Joaquin Rivers, and other streams of California as far southward as San Luis Obispo. "It is sent in small numbers to the markets of San Francisco, and is chiefly eaten by the Chinese."

One of the most remarkable groups of fishes has its headquarters in India, though a few species are found in Africa. Their peculiarity is chiefly exhibited in the complication of the pharyngeal bones and the contiguous parts. In allusion to this complication the group was long ago called by Cuvier the fishes with labyrinthiform pharyngeals.

The upper elements of one of the pairs of the gill-bearing arches are peculiarly modified. The elements in question (called branchihyal) of each side, instead of being straight and solid, as in most fishes, are excessively developed and provided with several thin plates or folds, erect from the surface of the bones and the roof of the skull, to which the bones are attached. These plates, by their intersection, form chambers, and are lined with a vascular membrane, which is supplied with large blood vessels. It was formerly supposed that the chambers referred to had the office of receiving and retaining supplies of water which should trickle down and keep the gills moist; such was supposed to be an adaptation for the sustentation of life out of the water. The experiments of Surgeon Day, however, throw doubt upon this alleged function, and tend to show, (1) that these fishes died when deprived of access to atmospheric air, not from any deleterious properties either in the water or in the apparatus used, but from being unable to subsist on air obtained solely from the water, aërial respiration being indispensable; (2) "that they can live in moisture out of the water for lengthened periods, and for a short but variable period in water only;" and (3) that the cavity or receptacle does not contain water, but has a moist secreting

surface, in which air is retained for the purpose of respiration. "It seems probable that the air, after having been supplied for aërial respiration, is ejected by the mouth, and not swallowed to be discharged per anum." In fine, the two respiratory factors of the branchial apparatus have independent functions, (1) the labyrinthiform, or branchihyal portion, being a special modification for the respiration of atmospheric air, and (2) the gill filaments discharging their normal function. If, however, the fish is kept in the water, and prevented from coming to the surface to swallow the atmospheric air, the labyrinthiform apparatus becomes filled with water which cannot be discharged, owing to its almost non-contractile powers. There is thus no means of emptying it, and the water probably becomes carbonized and unfit for oxygenizing the blood, so that the whole of the respiration is thus thrown on the branchiæ. This will account for the fact that when the fish is in a state of quiescence it lives much longer than when excited, whilst the sluggishness sometimes evinced may be due to poisoned or carbonized blood. Figures of the labyrinthiform apparatus of three genera (*Anabas*, *Macropodus*, and *Osphromenus*), here given, will convey some idea of its relations and modifications. The fishes with labyrinthiform pharyngeals have been generally combined in one family; but some authors recognize three, the Anabantidæ, Osphromenidæ, and Helostomidæ.

The ANABANTIDÆ include those species which have the mouth of moderate size

FIG. 137. — Gill labyrinths of *Anabas*, *Macropodus*, and *Osphromenus*.

and teeth on the palate (either on the vomer alone, or on both the vomer and palatine bones). To the family belongs the celebrated climbing-fish.

The climbing-fish (*Anabas scandens*) is especially noteworthy for the movability of the sub-operculum. The operculum is serrated. The color is reddish olive, with a blackish spot at the base of the caudal fin; the head, below the level of the eye, grayish, but relieved by an olive band running from the angle of the mouth to the angle of the pre-operculum, and with a black spot on the membrane behind the hindermost spines of the operculum.

The climbing-fish was first made known in a memoir, printed in 1797, by Daldorf, a lieutenant in the service of the Danish East India Company at Tranquebar. Daldorf called it *Perca scandens*, and affirmed that he himself had taken one of these fishes, clinging by the spine of its operculum in a slit in the bark of a palm (*Borassus flabelliformis*) which grew near a pond. He also described its mode of progression; and his observations were substantially repeated by the Rev. Mr. John, a missionary resident in the same country. His positive evidence was, however, called into question by those who doubted on account of hypothetical considerations. Even in popular works, not generally prone to even a judicious skepticism, the accounts were

stigmatized as unworthy of belief. We have, however, in answer to such doubts, too specific information to longer distrust the reliability of the previous reports.

Mr. Rungasawmy Moodeliar, a native assistant of Capt. Jesse Mitchell of the Madras government Central Museum, communicated to his superior the statement that "This fish inhabits tanks or pools of water, and is called *Panai feri*, *i. e.*, the fish that climbs Palmyra trees. When there are Palmyra trees growing by the side of a tank or pool, when heavy rain falls and the water runs profusely down their trunks, this fish, by means of its opercula, which move unlike those of other fish, crawls up the tree sideways [*i. e.*, inclining to the sides considerably, from the vertical] to a height of from five to seven feet, and then drops down. Should this fish be thrown upon the ground, it runs or proceeds rapidly along in the same manner (sideways) so long as the mucus on it remains."

These movements are effected by the opercula, which, it will be remembered, are unusually mobile in this species; they can, according to Capt. Mitchell (and I have verified the statement), be raised or turned outwards to nearly a right angle with the

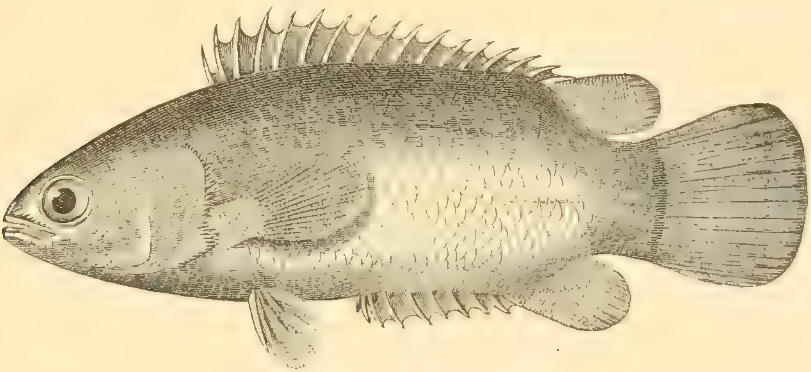


FIG. 138. —*Anabas scandens*, climbing-fish.

body, and when in that position the sub-operculum distends a little, and it appears that it is chiefly by the spines of this latter piece that the fish takes a purchase on the tree or on ground. "I have," says Captain Mitchell, "ascertained by experiment that the mere closing of the operculum, when the spines are in contact with any surface, even common glass, pulls an ordinary-sized fish forwards about half an inch," but it is probable that additional force is supplied by the caudal and anal fins, both of which, it is said, are put in use when climbing or advancing on the ground; the motion, in fact, is described as a wriggling one.

The climbing-fish seems to manifest an inclination to ascend streams against the current, and we can now understand how, during rain, the water will flow down the trunk of a tree, and the climbing-fish, taking advantage of this, will ascend against the downflow by means of the mechanism already described, and by which it is enabled to reach a considerable distance up the trunk.

The OSPHROMENIDÆ are fishes with a mouth of small size, and destitute of teeth on the palate. To this family belong the gourami, whose praises have been so often sung, and which has been the subject of many efforts for acclimatization in France and elsewhere by the French.

The gourami (*Osphromenus goramy*) has an oblong oval form, and, when mature, the color is nearly uniform, but in the young there are black bands across the body,

and also a blackish spot at the base of the pectoral fin. The gourami, if we can credit reports, occasionally reaches a gigantic size, for it is claimed that it sometimes attains a length of six feet, and weighs one hundred and fifty pounds, but if this is true, the size is at least exceptional, and one of twenty pounds is a very large fish; indeed, they are considered very large if they weigh as much as twelve or fourteen pounds, in which case they measure about two feet in length.

The countries in which the gourami is most at home lie in the intertropical belt. The fish is assiduous in the care of its young, and prepares a nest for the reception of the eggs. The bottom selected is muddy, the depth variable within a narrow area, that is, in one place about a yard, and near by several yards deep.

They prefer to use for the nests, tufts of a peculiar grass (*Panicum jumentorum*), which grows on the surface of the water, and whose floating roots, rising and falling

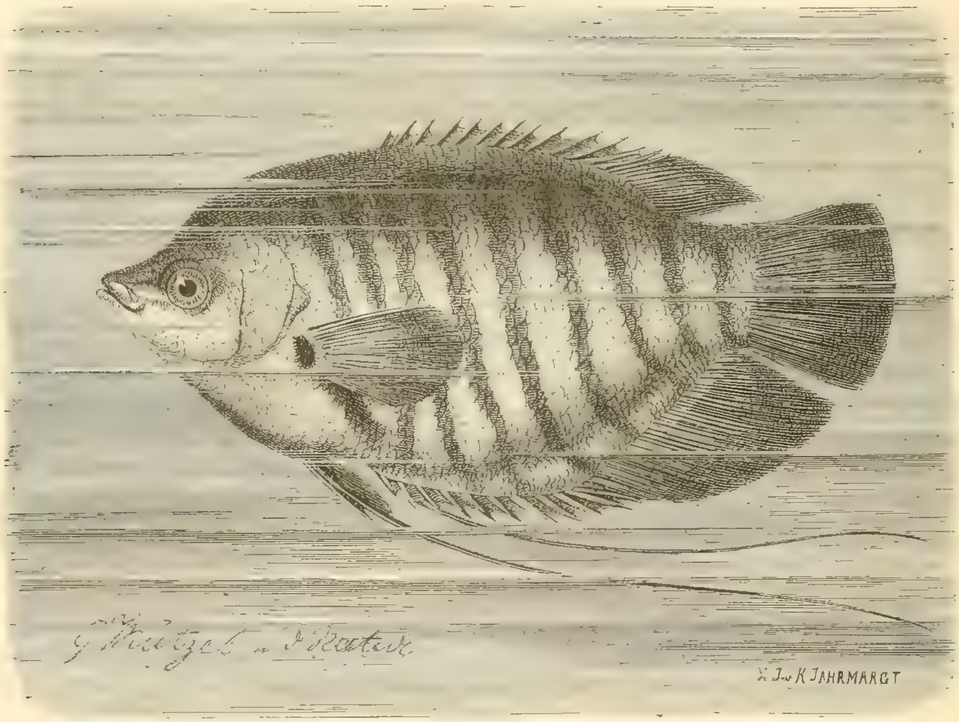


FIG. 139. — *Osphromenus goramy*, gourami.

with the movements of the water, form natural galleries, under which the fish can conceal themselves. In one of the corners of the pond, among the plants which grow there, the gouramis attach their nest, which is of a nearly spherical form, and composed of plants and mud, and considerably resembles in form those of some birds.

The gourami is omnivorous, taking at times flesh, fish, frogs, insects, worms, and many kinds of vegetables; and, on account of its omnivorous habit, it has been called by the French colonists of Mauritius *porc des rivières*, or 'water pig.' It is, however, essentially a vegetarian, and its adaptation for this diet is indicated by the extremely elongate intestinal canal, which is many times folded upon itself. It is said to be especially fond of the leaves of several araceous plants. Its flesh is, accord-

ing to several authors, of a light yellow straw-color, firm and easy of digestion. They vary in quality with the nature of the waters inhabited, those taken from a rocky river being much superior to those from muddy ponds; but those dwelling at the mouth of rivers, where the water is to some extent brackish, are the best of all. Again, they vary with age; and the large, overgrown fishes are much less esteemed than the small ones. They are in their prime when three years old. Dr. Vinson says the flavor is somewhat like that of carp; and, if this is so, we may entertain some skepticism as to its superiority; but the unanimous testimony in favor of its excellence naturally leads to the belief that the comparison is unfair to the gourami.

Numerous attempts have been made by the French to introduce the gourami into their country, as well as into several of their provinces; and, for a number of years, consignments of the eggs, or the young, or adult fish, were made. Although at last partially successful, the fish has never been domiciliated in the Republic, and, indeed, it could not be reasonably expected that it would be, knowing, as we do, its sensitiveness to cold, and the climates under which it thrives.

The fish of paradise (*Macropodus viridi-auratus*) is a species remarkable for its beauty and the extension of its fins, and especially of the ventrals, which has obtained for it the generic name *Macropodus*. To some extent, this species has also been made the subject of fish culture, but with reference to its beauty and exhibition in aquaria and ponds, like the gold-fish, rather than for its food qualities.

The only other fish of the family that needs mention is the fighting fish (*Betta pugnax*). It is cultivated by the natives of Siam, and a special race seems to have been the result of such cultivation. The fishes are kept in glasses of water, and fed, among other things, with the larvæ of mosquitoes, or other aquatic insects. "The Siamese are as infatuated with the combats of these fish as the Malays are with their cock-fights, and stake on the issue considerable sums, and sometimes their own persons and families. The license to exhibit fish-fights is farmed, and brings a considerable annual revenue to the king of Siam. The species abounds in the rivulets at the foot of the hills of Penang. The inhabitants name it 'Pla-kat,' or the 'fighting fish.'"

The name mullet has been given along the eastern coast of the United States, and, indeed, in most other places where English is spoken, to the Percesoces, which are treated of under the name Mugilidæ (p. 179); but the mullet or *mullus* of the ancients was a very different fish, and is the one which is now known under the name sur-mullet, or red mullet. This is the type of a distinct family (MULLIDÆ), of which a number of species, chiefly inhabiting the tropical seas, are known; the sur-mullet, or common species of Europe, being the most northern member. All the species have a moderately long, compressed body, which declines backwards from the shoulders, and is covered with large scales; an oblong head, more or less abruptly decurved in front of the eyes; varying dentition; two dorsal fins, the first with seven or eight spines, the second distant from it and like the anal — both oblong; and the ventral fins are somewhat pointed and compressed, and have each a spine and five rays. The chief distinctive feature, however, is the presence of two barbels behind the chin. The color in most all is more or less reddish, or approaching to reddish.

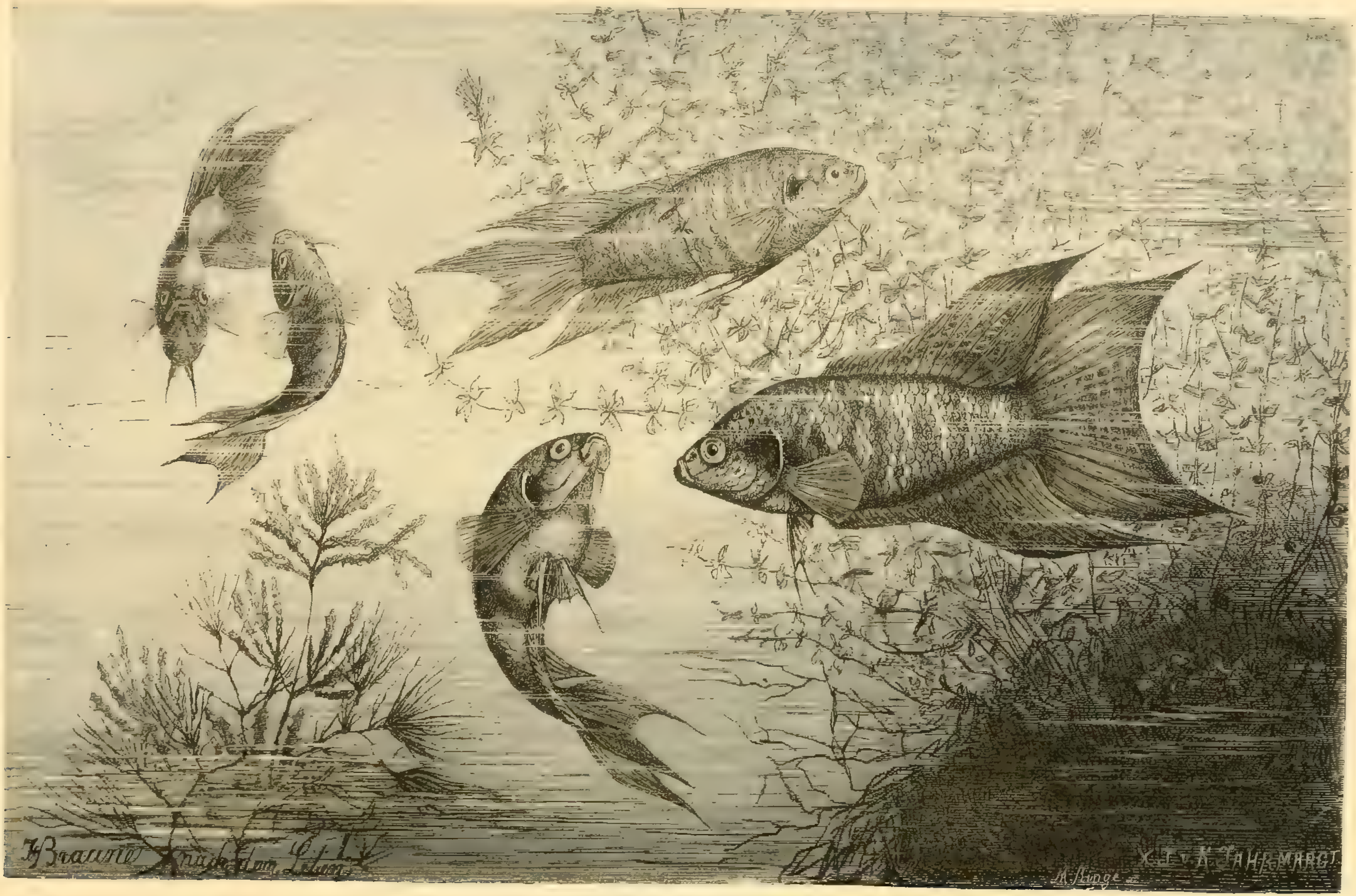
The sur-mullet (*Mullus barbatus*), was held in high esteem among the ancient Romans, and they placed it above all other fishes, with the exception, perhaps, of the scarus; as we learn from ancient satirical poets, as well as historians, enormous prices were paid for a fine fish, and it was the fashion to bring the fish into the dining-room and exhibit it alive before the assembled guests, so that they might gloat over the bril-

liant and changing colors during the death agonies. Even now the red color is regarded as almost an essential of a fine fish, and it is rendered distinct, on the part of the fishermen, by scaling it immediately after being taken. This operation produces a contraction of the chromatophores or cells containing the red pigment which colors the fish. The species extends as far north as the British islands, and even occasionally further northward along the continental shore. Although still regarded as a fine fish, it has lost in estimation from the imperial Roman days.

We have next to consider a series of forms almost all of which have an elongated body, and a short spinous dorsal fin, or spinous portion of a single dorsal fin, and which, for the greater part, inhabit tropical seas or the Antarctic. One of the most important of these is the Latilidæ.

The Latilidæ are compressed fishes with the dorsal scarcely divided or not divided at all; the spines few in number; the head compressed, the profile more or less abruptly decurved in front of the eyes, the opercular bones unarmed; the lateral line entire; the pectoral fins with branched rays, and the ventrals thoracic and each with a spine and five rays. Several interesting forms belong to this group, but only two can be mentioned in this place.

One of the most extraordinary episodes in fish life has been manifested in one of the species of this family. The species is a deep-sea form, named *Lopholatilus chamæleonticeps*, and which bears the 'English' name tile-fish. This name, by which it is quite generally known to the fishermen of the Massachusetts coast, is not of true popular origin, but is simply a part of the name *Lopholatilus*, and was suggested by Professor Goode. The fish was unknown until 1879, when specimens were brought by fishermen to Boston from a previously unexplored bank about eighty miles southeast of No Man's Land, Mass. In the fall of the year 1880 it was found to be extremely abundant everywhere off the coast of southern New England, at a depth of from seventy-five to two hundred and fifty fathoms. The form of the species is more compressed, and higher, than in most of the family, and what especially distinguishes it is the development of a compressed "fleshy fin-like appendage over the back part of the head and nape, reminding one of the adipose fin of the Salmonids and cat-fishes." It is especially notable, too, for the brilliancy of its colors, and as well as for its large size, being by far larger than any other member of its family. A weight of fifty pounds or more is, or rather, one might say, was, frequently attained by it, although such was very far above the average, that being little over ten pounds. In the reach of water referred to, it could once be found abundantly at any time, and caught by hook and line. After a severe gale in March, 1882, millions of tile-fish could be seen, or calculated for, on the surface of the water for a distance of about three hundred miles from north to south, and fifty miles from east to west. It has been calculated by Captain Collins that as many as one thousand four hundred and thirty-eight millions were scattered over the surface. This would have allowed about 288 pounds to every man, woman, and child of the fifty million inhabitants of the United States! On trying at their former habitat the next fall, as well as all successive years, to the present time, not a single specimen could be found where formerly it was so numerous. We have thus a case of a catastrophe which, as far as has been observed, caused complete annihilation of an abundant animal in a very limited period. Whether the grounds it formerly held will be reoccupied subsequently by the progeny of a protected colony remains to be seen, but it is scarcely probable that the entire species has been exterminated.



Macropodus viridi-auratus, Paradise fish.

Along the coasts of Florida, and also upon the coasts of southern California, are found fishes which belong to a genus apparently related to the *Lopholatilus* and *Latilus*, but which is distinguished by the greater number of rays of the dorsal and anal fins. The species of the east is known as the *Caulolatilus chrysops;* and there is no proper English name, although the Spanish name, blanquillo, is partially used. The species of the west coast, however, *Caulolatilus princeps*, is quite abundant from Monterey southwards, and is known under the name of white-fish or yellow-tail. It may be noted that white-fish involves nearly the same allusion in English as blanquillo does in Spanish.

Other fishes related to the Latilidæ have been segregated in families called BATHYMASTERIDÆ and MALACANTHIDÆ, and these are very near indeed, and might even belong to the same family. Still others, distinguished as the families PERCOPHIDIDÆ, NOTOTHENIIDÆ, HARPAGIFERIDÆ, OPISTHOGNATHIDÆ, PSEUDOCHROMIDIDÆ, ICOSTEIDÆ, and SILLAGINIDÆ, have also been approximated to the Latilidæ, and, indeed, combined with still others in one "family" called TRACHINIDÆ by Dr. Günther, but several of them, at least, are not at all nearly related.

One fish that perhaps belongs near some of these just mentioned deserves notice, as it manifests an apparent anomaly; it can take in, whole, another fish perhaps eight to twelve times larger than itself!

Chiasmodon niger, or the black swallower, is the fish that can perform this seemingly impossible feat. It has no near relatives, and is the type of a peculiar family—the CHIASMODONTIDÆ. Its body is elongated, of nearly uniform thickness to or behind the anus, and thence slightly tapering into the tail; the skin is naked; the head sub-conic and narrowed forwards; the mouth is very deeply cleft, extending behind the eyes, and armed with long, pointed, and in part movable teeth. There are two dorsal fins, the first having eleven slender spines; the second is elongated, and the anal is like the latter; the ventrals are thoracic, and have each a spine and five rays. Such is its appearance with an empty stomach. But it espies a fish many times larger than itself, but which, nevertheless, may be managed; it darts upon it, seizes it by the tail, and gradually climbs over it with its jaws, first using one and then the other; as the captive is taken in, the stomach and integuments stretch out, and at last the entire fish is passed through the mouth and into the stomach, and the distended belly appears as a great bag, projecting out far backwards and forwards, over which is the swallower, with the ventrals dislocated, and far away from their normal place. The walls of the stomach and belly have been so stretched that they are transparent, and the species of the fish can be discerned within. But such rapacity is more than the captor itself can stand. At length decomposition sets in, the swallower is forced belly upwards, and the imprisoned gas, as in a balloon, takes it upwards from the depths to the surface of the ocean, and there, perchance, it may be

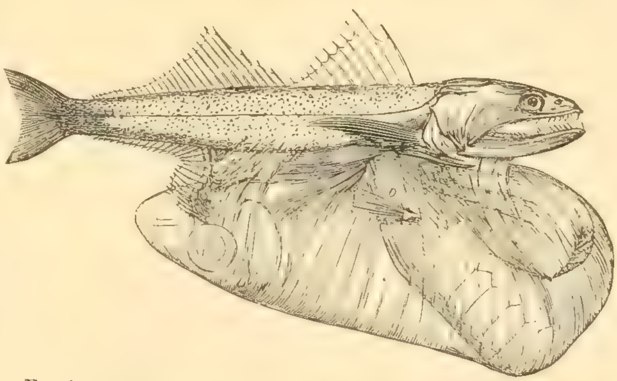


FIG. 140. — *Chiasmodon niger* which has swallowed a large *Scopelus.*

found and picked up, to be taken home for a wonder, as it really is. Thus have at least three specimens found their way into museums, — one being in the United States National Museum, — and in each the fish in the stomach has been about twice as long, and stouter in proportion, than the swallower — six to twelve times bulkier! Its true habitat seems to be at a depth of about 1,500 fathoms.

Now there comes up for consideration a long and composite series of fishes, which commences fairly enough with forms like ordinary fishes, — the Sebastines, — so much so that they have been called perch, on account of their likeness to the sea-perches. They are clean-looking, compactly built fishes, with scales as in the perches. But even closely allied to them are forms — the Scorpænines — that show the tendency of some of the divergent members of the series. There are, however, various types which diverge in different directions, and at one extreme are to be found species with coats of mail composed of large plates, and at another fishes with the body almost shapeless, and the naked skin so loose that they seem enclosed in a bag. All have the lower rays of the pectoral fins simple and more or less thickened and enlarged, and each cheek is crossed by a 'stay' or enlarged suborbital bone, which extends from the eye to the inner margin of the preopercle. But there are some fishes which do not have the armed cheeks, although the lower pectoral rays are simple and enlarged. Such are the Cirrhitidæ.

The Cirrhitidæ are compressed oval fishes, with smooth scales and the spinous portion of the dorsal long. The typical species are inhabitants of the tropical seas, although not of the West Indian. Others, however, constituting the subfamilies Chilodactylinæ and Chironeminæ, are denizens of the temperate seas, chiefly of the southern hemisphere, although a few occur along the Asiatic coast. Several of the species are important economical fishes, and are among the most prized of the Australian and New Zealand markets. The trumpeter (*Latris hecateia*), for example, is thought to be "the best flavored of any" of the New Zealand fishes.

The following have the cheeks armed, and for that reason were grouped together by Cuvier as the fishes with mailed cheeks, and have been also called Loricati, and by various other names of like import.

The Scorpænidæ are the least unlike ordinary fishes. The body is compressed, and covered with small or moderate scales; the head is more or less armed with ridges or spines above, and the operculum has about five flat spines along the margin. The spinous portion of the dorsal has usually ten to twelve (sometimes fifteen) spines; the anal has three spines. The pectorals are moderately procurrent at the base; and the ventrals are thoracic, sometimes appreciably behind the bases of the pectorals, and have generally a spine and five rays. Many are the species, and some coincidences are noteworthy. The tropical species have ten abdominal and fourteen vertebræ; numerous species along the western coast of the United States have twelve abdominal and fifteen caudal vertebræ; and a couple of species, constituting the genus *Sebastes*, confined to the cold waters of the northern Atlantic, have twelve abdominal and nineteen caudal vertebræ. Many, at least, of the species are ovo-viviparous. One of the most notable features of the Pacific coast of northern America is the great number of representatives of this family living at various depths. About thirty species have been made known, and among them are some of the most important of the economical fishes of the country. According to Prof. Jordan, "all of them are excellent food fishes, and scarcely a boat returns from any kind of fishing in which these fishes do not form a conspicuous part of the catch." They are chiefly known as rock-fish and rock-cod,

unfortunate names, for the former has long been in use for the *Roccus lineatus*, otherwise known as striped bass; and the latter is employed for cod caught on rocky bottoms, and is inapplicable to the Scorpænids, because they are entirely unlike the cod. Garrupa, the parent name of grouper, is also given to some species, likewise unfortunately, for the fishes best known by those names are Serranids: but, worst of all, several species are called black-bass, and may thus be confounded with the entirely unlike famed fresh-water fishes to which the name originally was applied. A few of the Californian species are so prominent as to deserve notice. The genus which has given a name to the family, *Scorpæna*, is represented by one species, the *S. guttata*. This is known as the scorpene, scorpion, and sculpin. "It is found only from Point Conception southward to Ascension Island." As a food fish, Prof. Jordan thinks "it ranks with the best, being superior to the species of *Sebastichthys*, and it always is in good demand where known." It is to the genus *Sebastichthys* that almost all of the Californian Scorpænids belong. The red rock-fish (*S. ruber*), it is said, "probably reaches a larger size than any other species, attaining a weight of twelve or more pounds," and in the markets of San Francisco is one of the most common fishes. The brown rock-fish (*S. auriculatus*) is exceptional in living in shallow water, "entering all the bays, and being taken with a hook from all the wharves." It attains a weight of three or four pounds, but, "as a food fish, it is held in lower esteem than most of the others." One species is so different from all the others in its longer form, smaller scales, and very projecting lower jaw, that it is placed in a different genus — *Sebastodes*. It is the *S. paucispinis*, and is the jack of the American fishermen, the boccacio of the Italians, and merou of the Portuguese, about San Francisco. It grows to a large size, — twelve to fifteen pounds, — and its flesh is considered excellent. It is said to be the most voracious of its family, and the Italian name, boccacio, meaning big-mouth, refers to its capacity for ingestion of prey.

The *Sebastes marinus* and *S. viviparus* are the only North Atlantic species of the family, and are so nearly alike that they are by many considered to be the same. As understood by others, however, the *S. marinus* is a large red fish living in deep water, while the *S. viviparus* is a small, banded species, frequenting shallow water. The *S. marinus* is variously known as the rose-fish, red-fish, red-perch, Norway haddock, John Dory, etc. The supply for the eastern markets is mostly restricted to those of Massachusetts.

In the next family which we need consider — the Cottidæ — a decided step in the path of eccentricity is taken, and the extreme forms are very unlike the ordinary fishes. The body is rather elongated, and generally stoutest at the shoulders and graduated backwards; true scales are usually absent, rarely present in longitudinal bands, less rarely represented by plates or bucklers along the lateral line, and sometimes replaced by prickles over the body; the head is generally broad and the cheeks tumid, the crown spiniferous, and the preoperculum and operculum usually armed with spines; a distinct anterior short dorsal, with approximated spines is the rule; the second dorsal and anal are larger, and the latter spineless; the pectorals have very procurrent bases, and the ventrals are generally imperfect, that is, provided with less than five rays, or rarely absent. The species are quite numerous, mostly confined to the cold seas of the northern hemisphere, and especially well represented by diverse types along the western American coast. The least aberrant of the family appear to be the genera *Hemilepidotus* and *Scorpænichthys*, both of which are confined to the north Pacific.

The *Scorpænichthys marmoratus*, known along the Californian coast as cabezon, sculpin, scorpion, salpa, and big-head (the last having the same meaning as cabezon), is the largest of the family, and the only one brought habitually to the markets. It attains a length of ten to fifteen pounds, and is distinguishable by the development of eleven dorsal spines and five ventral rays.

The sculpins of the north Atlantic constitute the genus *Cottus* and have the gill membrane free around the margin, and the spines of the head are very stout. Three species occur along the coast of the Eastern States, — *C. octodecimspinosus*, *C. æneus*, and *C. grœnlandicus.*

The miller's-thumbs of the fresh waters belong to another genus named *Uranidea;* in these the gill-membrane is confluent with the skin of the throat, the gill holes being limited to the sides, and the spines of the head are very feeble and partly wanting.

FIG. 141. — *Cottus scorpio*, sculpin.

The species are quite generally distributed over the northern hemisphere, and are very closely related. The commonest of European species is *U. gobio*, and of American, *U. gracilis* and *U. viscosa.*

There are certain fishes, the largest and best known of which is commonly called the lump-fish, which constitute a peculiar family — CYCLOPTERIDÆ — apparently related to the Cottidæ, although they have been generally widely separated from them. The body is short and tumid, and tubercles generally surmount the skin, but sometimes they are wanting, leaving the surface smooth; the head is short and wide and covered by the skin, all armature being suppressed; there are two dorsals; the first is short and spiniferous, but sometimes overgrown by the skin; the pectorals have wide procurrent bases, and, above all, the ventral fins are united in a circular disk. The bones are imperfectly ossified, and the entire appearance indicates that the species are the degenerate descendants of nobler fishes. They are most nearly

related to fishes called Liparididæ, which, in their turn, are related to the Cottidæ, and thus indirectly the affinities of the Cyclopteridæ have been traced.

The common lump-sucker — *Cyclopterus lumpus* — is by far the largest of the family. It rejoices in many names in addition to lump-sucker, such as lump-fish, sea-owl, cock-paidle, hen-paidle. It may be at once recognized by the tubercles which cover the skin, some of which are enlarged, spiniferous, and arranged in seven longitudinal rows, a median dorsal, and three on each side; a hump becomes developed with age on each side of the spinous dorsal, thus concealing it; the ventral disk is

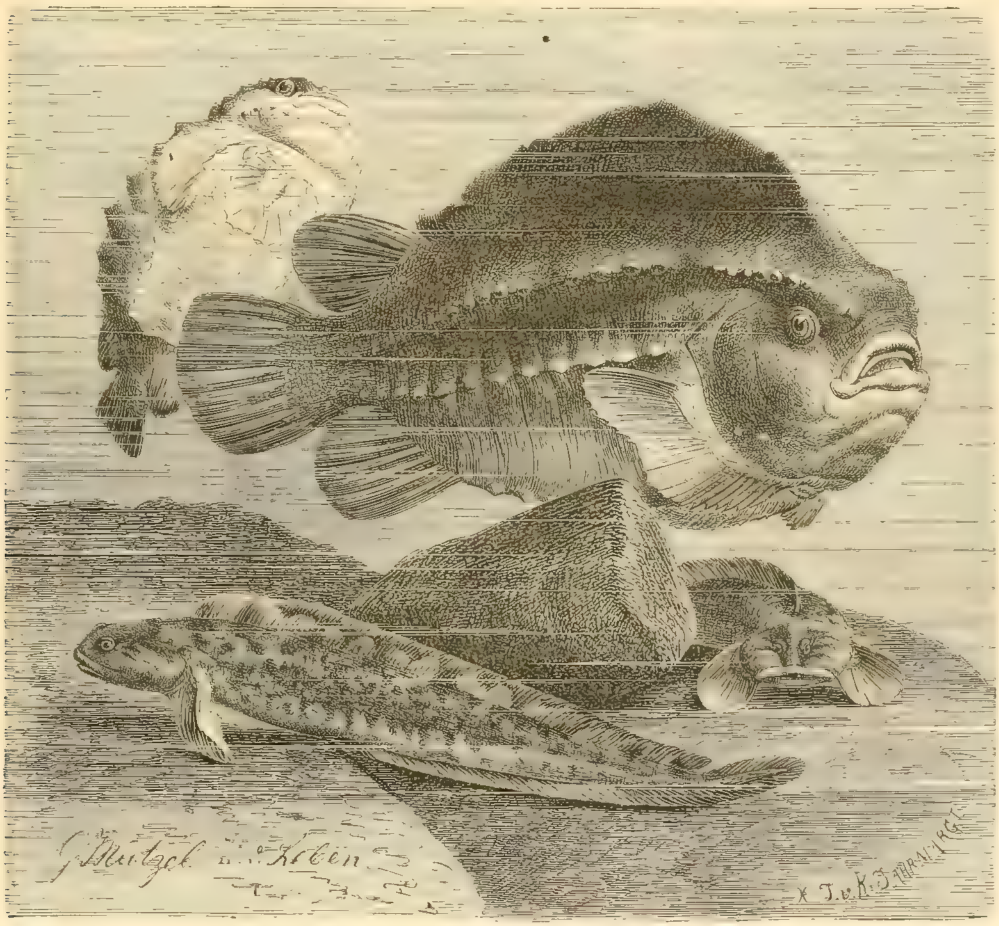


FIG. 142. — *Cyclopterus lumpus*, lump-fish, and *Zoarces viviparus*.

small. Sometimes it reaches a considerable size, a Massachusetts specimen eighteen and three-fourths pounds having been reported, but the largest English one found weighed only eleven and a half pounds. Both of these were giants, and the average is very much smaller.

The lump-sucker, in the well-considered words of Benecke, "lives on the bottom of the sea, swims slowly and with difficulty, and in May and June comes into shallow water to spawn. The male makes pits in the sand between the stones, in which the female deposits its eggs. The male watches over the eggs, and later over the tender young,

which cling to its body with their suckers. The number of eggs ranges from 200,000 to 400,000. It is a voracious species, which preys upon small crustaceans, molluscs, and fish-spawn." The observations thus epitomized were made in the southern Baltic.

The lump-sucker is really very good, although there is quite a general prejudice against it on account of its 'uncanny' appearance. Those who are familiar with Walter Scott's 'Antiquary' may remember that Mr. Oldbuck gave as much for a fish of this kind as he did for a turbot.

Still other of the mail-cheeked fishes are distinguished by the armature of the head and distance of the ventrals from each other. The body is elongate conical, declining backwards from the head; scales or plates cover the trunk; the head is quadrate, angulated, covered with bony plates, and the jaws are overarched by and retractile under the preorbital plates; there are two dorsals, an anterior short, spiniferous one, and a longer posterior rayed fin, to which is opposed a similar anal; the pectorals have three or two lower rays entirely detached and independent, developed as enlarged tactile organs; the ventrals are separated by a wide flattened area, and are perfect, that is, have a spine and five rays each. Two quite distinct groups are kept in this family, the Triglinæ, with scales and three free pectoral rays, and the Peristediinæ with plates and two free rays.

The Triglinæ are mostly shallow-water fishes, and may at times be seen progressing near the ground, often in curves or a zig-zag course, sometimes leisurely, sometimes hurrying up, with the snout more or less downward, and the free pectoral rays curved forward and downward, and used, partly for locomotion, and partly as feelers. Rather curiously for such northern forms, one genus (*Trigla*) with many species is found in Europe and not in America, while another (*Prionotus*) with several species is confined to America. The *Triglæ* are mostly called gurnards in England, while the *Prionoti* are chiefly known as robins or sea-robins along the American coast. Mr. Goode informs us that the sea-robins have excellent food qualities, but are eaten, so far as we have record, only in the vicinity of Hartford, Conn., where they are known as "wing-fish." It is queer that we have to go into an inland town to learn the worth of a common sea-fish. A dweller near salt water, however, and a very competent judge of what is good for the table, Mr. J. Carson Brevoort, thinks that a sea-robin is "one of the most delicate morsels that can be laid before an epicure, the flesh being snow-white, firm, and fully as good as that of the king-fish, or whiting. In fact it would be hard to distinguish them when placed on the table." The European species are also mostly favorably regarded for the table.

Next comes a small group of fishes of family rank, named CEPHALACANTHIDÆ or DACTYLOPTERIDÆ, closely related to the Triglidæ, but distinguished by some salient features. The body is also elongate conical, and is covered by regular but keeled scales; the head is of a parallelopiped form, covered with bony plates, and the preoperculum extends backwards in a long spine; the first dorsal fin is short, and has only four or five slender spines, of which the first two are nearly free; the second is little longer, and the anal is quite short; the pectorals are singular in being divided into two parts, an upper narrower, and a lower much larger and more elongated portion, whose rays are all connected together; the ventrals are imperfect (having only one spine and four rays) and comparatively near each other. What further especially distinguishes the group is a coalescence of the anterior vertebræ (about four) into a tubiform body.

The species are few in number, but interesting in habits. They are pelagic fishes,

and their enlarged pectorals are adaptable for short flights through the air. Hence they have received, in common with the Exocœtines, the name of flying-fishes, and are also called flying-robins, and bat-fishes. They are not, however, as good flyers as most of the Exocœtines. They associate together in schools, and are mainly inhabitants of the warm seas, although the best known species, *Cephalacanthus* or *Dactylopterus volitans*, reaches quite a high latitude, for instance, the banks of Newfoundland. Sometimes individuals reach a length of eighteen inches, but twelve inches is a much more usual size. The changes undergone in course of growth are quite remarkable, the young having comparatively short pectorals, and being otherwise different, so that it was formerly considered to be a distinct generic type, the name *Cephalacanthus* being given to it, while the old was known as *Dactylopterus*. The American naturalists have adopted the former name instead of the latter, because it was the first given; it is also the best, and alludes to one of the most characteristic features, the long spines of the preoperculum, while *Dactylopterus*, meaning fingered fin, implies just what it has not, and the absence of which is one of the characters distinguishing it from the Triglidæ.

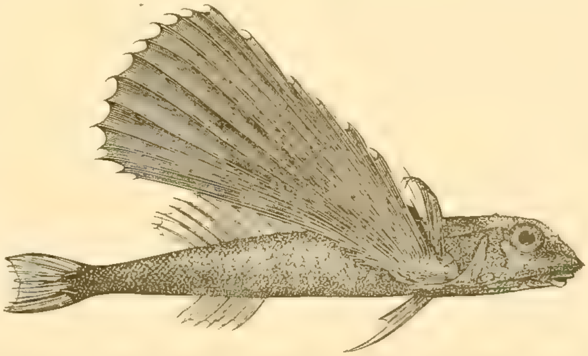


FIG. 113. — *Cephalacanthus volitans*, flying-fish, flying-robin, bat fish.

A family quite characteristic of the North Pacific is one called CHIRIDÆ. They may be known by the compressed oblong, or rather elongated, body, the long double dorsal, of which the spinous and soft parts are nearly equal, and the perfect thoracic ventral fins. There are four different groups or subfamilies.

The species of one group are quite generally known as rock-trout. They have, in addition to the lateral line, other lines near the back, and near the belly and anal fin. Besides rock-trout, they are called, in common with the Scorpænidæ, rock-cod, and also sea-trout, boregata or boregat, bodieron and starling. They live chiefly in moderately deep water, and feed mainly on crustaceans and small fishes. Two species (*Hexagrammus lagocephalus* and *H. decagrammus*) occur along the Californian coast, and another (*H. stelleri*) is common farther northward. They are pretty nearly of the same size, growing to a length of about fifteen inches, and a weight of two or three pounds. As food fishes they are of "fair quality." The *H. decagrammus* "dies at once on being taken from the water, and the flesh becomes rigid and does not keep as well as the other rock-fish."

A better and larger fish of the family is one generally known at San Francisco as the cod-fish (*Ophiodon elongatus*); it is also called bastard cod, cultus cod, green cod, buffalo cod, etc. The form is more regularly elongate than in the other Chiridæ, and there are no supernumerary lateral lines. It sometimes reaches a length of five feet, and a weight of fifty or sixty pounds. "As a food-fish it holds a high rank, being considered rather superior to the rock-fish," or the species of *Sebastichthys*, etc., and "from its great abundance, it is one of the most important fishes on the Pacific coast."

Nearly related to the Chiridæ is a fish which, by itself alone represents a peculiar family — the ANOPLOPOMIDÆ. It is an elongate fish, with fins much like those of the

Chiridæ, but the head is wide and flattish above. In appearance it is much like a pollock, and, indeed, has more than once been mistaken for a relation of that cod-fish by naturalists. It is known as the candle-fish, black candle-fish, horse-mackerel, and beshow. It grows to a length of twenty inches, weighing about five pounds. "As a food-fish it is held in low esteem," but is "sometimes fraudulently sold as spanish-mackerel," — a most underserved slur on a royal fish.

Other families of the mail-cheeked series, more or less related to one or other of the families described, are the CARACANTHIDÆ, SYNANCEIDÆ, HEMITRIPTERIDÆ, AGRIOPODIDÆ, PLATYCEPHALIDÆ and HOPLICHTHYIDÆ; but, interesting as some are, we must leave them with the mention, only adding that it is to the Hemitripteridæ, that the sea-raven of the American coast belongs.

A family related, though distantly, to the mailed-cheeked fishes, Synanceidæ, is that of the URANOSCOPIDÆ, to which the popular name of star-gazer is given on account of the eyes being placed on the upper surface of the head; the scientific has the same meaning. The head is flattened and almost rectilinear from the nape to the mouth; the mouth itself is very oblique. Several species of the family are found along the American coast, the largest being the *Astroscopus guttatus.* This has the head protected by bone above, but with a couple of spaces occupied by bare skin, and it is said that these bare spots give an electric shock. Although this is quite generally believed, it requires scientific confirmation.

Another family of interest in this series is that represented by the weevers of England, and known scientifically as the TRACHINIDÆ. These are distinguished by an elongated body, attenuated backward from the head, a compressed, oblong head, with the snout very short, a deeply cleft oblique mouth, and a long spine projecting backward from each operculum, and strengthened by extension on the surface of the operculum, as a keel. The dorsal fins are distinct, the first composed of strong, pungent spines, radiating from a short base, and about six or seven in number. The second dorsal and anal are very long. The pectorals have the lower rays unbranched; and the ventrals are in advance of the pectorals, and have each a spine and five rays. The species of this family are mostly found along the European and western African coast; but, singularly enough, a species closely related to the old-world form is found on the coast of Chili. None have been obtained from the intermediate regions, or from the American coast. Two species are found in England, and are known under the name of the greater weever (*Trachinus draco*), about twelve inches long, and the lesser weever (*Trachinus vipera*), about six inches long. They are perhaps the most dreaded of the smaller English fishes. The formidable opercular spines are weapons of defence; and, when seized by the fisherman, the fish is apt to throw its head in the direction of the hand, and lance a spine into it. The pungent dorsal spines are also defensive. Although without a poison gland, such as some fishes, distantly related, have at the base of the spines, they cause very severe wounds, and death may occur from tetanus. They are therefore divested of both opercular and dorsal spines before being exposed for sale. The various popular names which the weevers enjoy, in addition to their general designation, mostly refer to the armature of the spines, or are the result of the armature; such are adder-fish, sting-fish, and sting-bull.

Two families of small fishes are closely related to the Uranoscopidæ, but do not demand special notice. They are the LEPTOSCOPIDÆ and DACTYLOSCOPIDÆ. Another, less closely related, is the TRICHODONTIDÆ.

There are many fishes which are known under the name of toad-fishes; but along the American coast the one so designated is the representative of a family known as the BATRACHIDÆ, this name embodying the same idea (likeness to the toad) that the popular one does. All the species of the family have a body which is highest at the shoulders, and which quite regularly decreases in height and width backwards to the tail. The head is somewhat cuboid, and flattened above, and the eyes at the edge of the flattened head, so that they generally look upwards. The mouth has a very oblique cleft. The first dorsal fin has two or three very strong pungent spines. The second dorsal and anal are longish. The pectorals have a wide base, decurrent forwards; and the ventral fins are considerably in advance of the pectoral.

The common toad-fish of the American coast (*Batrachus tau*) has a flabby body, without a lateral line, and three dorsal spines. The teeth on the jaws as well as on the vomer and palatines are mostly in a single row, and blunt. The jaws are very powerful, and a bite from the fish creates an impression far from pleasant. The fish holds on with the pertinacity of a bulldog to what he has taken hold of. It is apt to lurk in oyster beds, and the young are quite frequently found in the empty shells;

FIG. 144. — *Batrachus tau*, toad-fish.

hence one of the names given to the species is oyster-fish. The specific name, *tau*, is in allusion to the impression resulting from the ridges on the surface of the cranium, which resemble a T or the Greek letter tau.

Truly venomous fishes belong to this family of Batrachidæ. They constitute the genus *Thalassophryne*, of which two species are known, one living on the Atlantic, and the other on the Pacific coast of North America. The poison is secured in sacs at the base of the spinous dorsal fin, as well as of each of the opercular spines, which are hollowed out to serve as ducts for the poison secreted by the glands.

Most of the Batrachids are of small size, rarely exceeding a foot in length; but in the sea about the Seychelles islands, there is a gigantic species (*Phrynotitan gigas*, originally called *Batrachus gigas*), whose head is over two feet wide. It is covered with small scales, acute teeth are in bands on the jaws, vomer, and palatine bones, and the spinous head armature is very weak.

We may next consider several families of fishes which have been united under a superfamily named GOBIOIDEA. Their parentage was probably in common with the preceding families.

The family of GOBIIDÆ contains by far the largest number of species, about four

hundred being more or less satisfactorily known. Most of them have a stout body diminishing from the head to the tail, but some become quite elongated, and a few are compressed and oval; the scales in most have a pectinated hinder margin which is angulated at the middle, whence the striæ diverge forwards, but some of the scales are cycloid, and a number have only cycloid scales; few are entirely naked; there never is a lateral line; the head is generally short with bulging cheeks; the branchial

FIG. 143. — *Periophthalmus koelreuteri.*

apertures are more or less restricted to the sides; generally, there are two dorsal fins, and in most the first has six spines, of which the last is separated by a wider interval than are the others; in some, however, the spines are more numerous, and in others, the fin is continuous with the second; the ventrals are thoracic, and mostly have a spine and five rays, the inner of which are largest; in most there is also a connecting membrane in front between the spine, and behind between the innermost rays, resulting in a funnel-shaped sucker. Finally, a papilla is developed next the anus.

The species are mostly of small and even minute size, but a few reach moderate dimensions — between one and two feet. Some are quite peculiar for their habits.

On the Californian coast is a Gobiid (*Gillichthys mirabilis*) remarkable for the great extension backward of the jaws and singular habits. It chiefly lives in shallow places, left bare at low tide, and harbors in holes excavated by itself in the mud. Numbers are obtained, especially by the Chinamen, by digging. It is thought to taste somewhat "like eels."

Certain other species belonging to the genus *Periophthalmus* have large protuberant eyes and pectoral fins capable of being flexed downwards and forwards, and usable as legs. They frequent mud flats and coasts, and at low tide are left out of water, and progress then by regularly hopping, their fore fins or pectorals assuming the function of the hind limbs of kangaroos and other leaping mammals; they are assisted, however, by the tail. The prominent eyes, to which reference has been made, and which are very versatile, come into use for observation in different directions. This ability to progress on land enables them to pursue beach crustaceans as well as insects, and another object of pursuit is a slug-like gastropod named *Onchidium*. The species are confined to the coasts of the Indian oceans and western Africa. One of the most common is the *Periophthalmus koelreuteri*. Two or three closely related genera share their range in whole or part.

Other families generally associated with the Gobiidæ are OXUDERCIDÆ, CALLIONYMIDÆ, and PLATYPTERIDÆ. The Callionymidæ have the ventrals very far apart, a large preopercular spine, and very restricted gill-openings. The species, between thirty and forty, are mostly tropical, but one occurs along the British coasts, and is known as the dragonet or sculpin.

Still more aberrant fishes are now to be seen. They are numerous and diversified — so much so that not less than eleven families have been recognized for them, — but they may all be provisionally retained in the superfamily BLENNIOIDEA.

In appearance, at least, the least aberrant of the series are the CLINIDÆ. These have a moderately long or oblong body, and regular scales cover it; the head rather projects forwards, the dorsal has a very long spinous portion (the spines are stiff) and a shorter soft one, and jugular ventrals with a spine and two or three rays are developed. Of all the fishes which have already been treated of, the Chiridæ appear to be those to which they are most nearly related, and they may have sprung from a common stem, the Chiridæ being less and the Clinidæ much more modified.

The Clinidæ are mainly inhabitants of the tropical and subtropical seas, although several reach the coast of the United States, and one of the largest of the family — *Heterostichus rostratus* — occurs along the Californian slope.

The BLENNIIDÆ are also oblong or moderately elongated fishes, but with a naked skin; head more or less shortened or blunt; teeth movable in front; the dorsal with nearly equal inarticulate and articulate portions; the "spines" slender and flexible, and the jugular ventrals with the spine concealed or atrophied, and two or three thickened rays. The species are very numerous, although only about nine are to be found along the American coasts, most being inhabitants of tropical seas.

Some of the most remarkable of the Blenniids are those of the genus *Salarias*, and, as the generic name implies, they can leap sometimes many times their own length.

The largest of the Blennioid group are the formidable wolf-fishes, constituting the family ANARRHICHADIDÆ. These have an oblong but robust body, with rudimentary

scales, a head ending in a blunt curved profile, a deep-cleft and oblique mouth, strong canine teeth in front of the jaws, lateral tubercular teeth on the sides of the lower, and blunt pavement-like ones on the palate; the dorsal fin is very long, and has only slender spines, and ventral fins are absent. Half a dozen species only are known, all confined to the cold waters of the northern hemisphere, and represent two very different genera — *Anarrhichas* and *Anarrhichthys*.

The common wolf-fish of the North Atlantic (*Anarrhichas lupus*) is a stout fish, with a long median or vomerine band of teeth, reddish-brown, with some nine to twelve dark cross bands, and many dark spots. It reaches a large size. One of three feet long would weigh twenty pounds, and it has been said to occasionally attain a length of six or seven feet, which, at the same ratio, would imply a weight of at least one hundred and sixty pounds. There may be some mistake or exaggeration here.

FIG. 146. — *Anarrhichas lupus*, wolf-fish.

It ranges southward to France, in Europe, and New York on the American side, and perhaps even further down in deep and cold water; and its distribution has been said to be almost coincident with that of the halibut.

The wolf-fish has very powerful jaws, and uses them to break the shells of crabs, lobsters, and sea-urchins, as well as the much harder ones of clams and other shell-fish.

Savagery appears in the very appearance of the wolf-fish. "It is impossible," says Mr. Goode, "to imagine a more voracious-looking animal than the sea cat-fish [another of its names], with the massive head, and long sinuous muscular body, its strongly rayed fins, its vise-like jaws, armed with great pavements of teeth, — those in front long, strong, pointed, like those of a tiger." Its looks do not belie its character. It is a very pugnacious animal, and "has been known to attack furiously persons wading

at low tide among the rock-pools of Eastport, Maine." The fishermen, therefore, have to be very cautious in handling them, and take care to knock them on the head, and disable them, before leaving them in their boats or releasing them.

Withal, the wolf-fish has redeeming qualities — at least in death. Some consider it a "very delicate" and even "delicious" fish, but there is quite a general prejudice, on account of its repulsive appearance. When "properly dressed, and disguised by the head being cut off, it is considered equal to many of the marine fishes," is the more qualified praise of another who has tried it.

But it is not alone as a food fish that the wolf-fish is useful to man. "The skin is converted into very durable bags and pockets."

A distant relation of the wolf-fish — *Anarrhichthys ocellatus* — but more elongate, and with the dorsal and anal confluent with the caudal, lives along the Pacific coast of America, from Puget Sound to Monterey. "It reaches a length of eight feet, and a weight of about thirty pounds," but the average is "five to six feet." It is chiefly called eel, or wolf-eel. "As a food fish, it meets always with a ready sale."

Numerous other fishes are related to those we have just noticed, and belong to families named Patæcidæ, Nemophididæ, Chænopsidæ, Cebedichthyidæ, Stichæidæ, Xiphidiontidæ, Cryptacanthodidæ, Acanthoclinidæ, and Gadopsidæ, but these we must pass. It is possible that to this series also belongs a very curious North Pacific fish, called *Ptilichthys goodei* by Dr. Bean, and referred by him to the family Mastacembelidæ, which properly only embraces East Indian fresh-water fishes. It is certain that *Ptilichthys* does not belong with or near them, and (if we can trust the description) that it is the representative of a peculiar family (Ptilichthyidæ), but we must await its re-examination by a skilful morphologist, to learn what it really is.

The Acanthopterygians would cease with the types last considered; but there are several families which have been referred to the "order Anacanthini" that are closely related to the Blennioidea, and doubtless have a parentage in common with them.

The Zoarceidæ, or Lycodidæ, have some resemblance to the wolf-fishes. They are more or less elongated, with the tail tapering to the end, the head with a decurved profile, conic teeth, and the dorsal and anal with soft rays (except some at an interrupted interval in the dorsal behind) and confluent with the caudal; the ventrals are jugular and imperfect, or (rarely) altogether absent. The species are quite numerous in the arctic or deep seas; but a couple of species are found southward along the European and American coasts. The southernmost shallow-water Zoarceids constitute the genus *Zoarces*, which is distinguished by a break in the dorsal behind, and the replacement of the rays there by short, stubby spines. The European (*Z. viviparus*) is rather a small fish; but the American (*Z. anguillaris*) is comparatively large.

Mutton-fish, congo or conger eel, eel-pout, and lamper-eel are names bestowed on the *Z. anguillaris*. It reaches a length of some three feet, and weight of six or seven pounds. Its range is claimed to be from Labrador to North Carolina. Crustaceans and shell-fish constitute its chief food. As food itself, diversity of opinion exists, largely influenced, doubtless, by its unprepossessing appearance. The best judges, however, pronounce it tolerable, and one of its names (mutton-fish), by which it is known at Cape Ann, involves a comparison with sheep's flesh. Prof. Goode testifies to "the delicacy of its flavor."

The European *Zoarces* (*Z. viviparus*) Fig. 142, is best known on account of its viviparity. The female matures her eggs in her body, and living young come forth,

somewhere about three hundred in number. It comes in on "the border line between food and refuse fishes;" but "some people consider the flesh as very fine and wholesome."

The forms that come up next for review have been almost universally associated with the cod-fishes; but they are really but distantly related, and are nearer the preceding. The BROTULIDÆ are a family of which few species were known till the era of deep-sea dredging and trawling, but now there are many. The body is elongated, and tapers backwards to the end of the tail; small scales are immersed in the skin; the head is diversiform, but always has a large mouth; the branchial apertures are generally ample; the dorsal and anal are long (the dorsal especially), and generally covered with loose skin and scales; a caudal is developed, but narrow; the ventrals are jugular, very narrow, and, generally, with two rays.

Numerous species representing many genera, some possessed of very curious characters, inhabit the depths of the sea. Some have stout spines about the head and

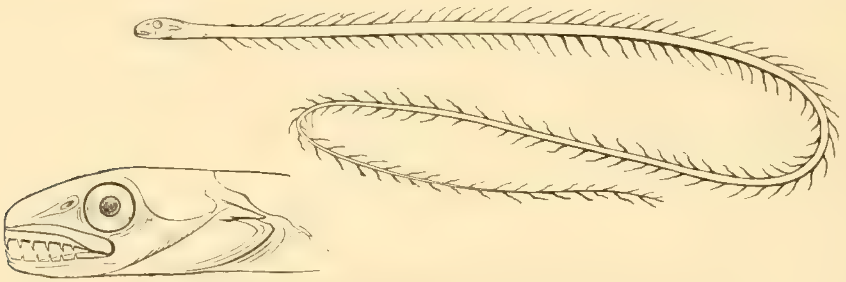


FIG. 147. — *Enchelicphis tenuis*, natural size, and head enlarged.

shoulders; and the inhabitants of very deep water are very loose and flaccid in appearance. Very few live in water of moderate depth. Among them are the name-giving genus of the family (*Brotula*) and a species found along the Californian coast (*Brosmophycis* or *Dinematichthys marginatus*). Only two others are specially noteworthy; they are blind fishes inhabiting fresh water in certain caves of Cuba; *Lucifuga subterranea* and *Stygicola dentata* are their names.

Closely related to the Brotulidæ are some fishes distinguished by the position of the ventrals at the chin, or between the rami of the lower jaw. These are the OPHIDIIDÆ. On account of this advanced position of the fins, they were supposed by the old naturalists to be a pair of bifid barbels, and the fishes were placed with the eels, as apodals. Most are of little value and small in size, but some species of the southern hemisphere become quite large and are in some repute for their flesh. One living in the sea round New Zealand (*Genypterus blacodes*) is known as the ling or cloudy bay-cod, and reaches a length of five feet and a weight of fifteen to twenty pounds; "it has white, flaky flesh that takes salt well."

Finally we have a few fishes constituting the family FIERASFERIDÆ, still smaller and more tapering backwards than the preceding, and differing from them by the entire absence of ventrals. They manifest a very singular phase of fish-life, for they chiefly live in the interior of other animals, especially holothurians. They have been especially studied by Prof. Carlo Emery, who watched their movements, and tells us how they enter into the holothurians. When free in the water, the fish swims head downwards, with tail curved toward the back, by undulatory movements of the anal fin. Coming to a holothurian lying at the bottom of the water, it eagerly seeks the

posterior aperture. Sometimes it penetrates through this head foremost, but generally enters in a characteristic manner. By its anal aperture the holothurian expels and sucks in water. The fish, during the expulsion of the water, pushes its head into the orifice, and curves its tail to one side, and then, by a rapid recoil movement, introduces itself, tail foremost, into the intestinal canal, pushing farther and farther in with every suction of its involuntary host. From the intestine it penetrates into the pulmonary passages, and thence, after their rupture, into the perivisceral space. It remains, however, near the anus, and protrudes its head, when hunger impels, in search of food. It is therefore neither a true parasite, since it does not feed on its host, nor a commensal, as it does not share the food of its host, but simply a lodger or tenant at will.

The last three families constitute a super-family — OPHIDIOIDEA — well marked off from all others by anatomical, especially osteological, characters. Others have been associated with them, but very little is known about them. Such are the BROTULOPHIDIDÆ, CONGROGADIDÆ, and CERDALAIDÆ.

Two other families approximated to the Ophidioidea are ATELEOPODIDÆ and XENOCEPHALIDÆ, but our information regarding them is in even a more unsatisfactory condition than about the others.

The super-family AMMODYTOIDEA, and family AMMODYTIDÆ, are a group of doubtful relations, although generally placed next to or among the Ophidioidea. They have a long, sub-cylindrical, or slightly compressed body, graduating into the tail; scales

FIG. 148. — *Ammodytes americanus*, sand-eel, sand-launce.

often arranged in oblique folds, the lateral line near the back, the head pointed, and with the lower jaw extended forwards, and the operculum and sub-operculum much enlarged; the dorsal fin is composed solely of articulated rays, and occupies most of the back; the anal fin is confined to the posterior half of the body; the caudal fin is furcate; the pectoral fins are high on the scapular arch, and have all the rays branched, and ventral fins are entirely absent. The species are rather few in number, and mostly confined to the northern temperate seas, although a peculiar generic type (*Bleekeria*), closely related to the cold-water forms, is found along the Indian shores, but very sparingly. The species are known to the English-speaking people mostly under the name of launce, lant, or sand-eel.

Three species are found along the British shores, but one of them is very rare, an inhabitant of deep water; two species (*Ammodytes americanus* and *A. dubius*) occur along the American coast. The habits of all are essentially similar. They live on sandy shores, congregate together in large numbers, and, when alarmed, take to the sand, in which they rapidly plunge and force themselves, and remain concealed. On account of their large numbers they form a very essential portion of the food of many fishes, and especially the cod-fishes, and they are also much used as bait. They rarely reach a length beyond a foot. They are chiefly captured at ebb-tide by digging into the sand, and hoes and rakes, as well as spades, are put into requisition for this purpose. "Sand-eeling excursions by moonlight, at the low spring tides in the sandy bays of

the islands Jersey and Guernsey, constitute a favorite and highly exciting pastime, indulged in, in summer time, by the members of both sexes and all ranks."

The common sand-eel of the eastern coast of the United States, *Ammodytes americanus*, has from 125 to 130 lateral oblique folds, and the pectoral fins are much longer than the snout, extending as far back as the front of the dorsal; it has about 28 anal rays. It is very closely related to the common *A. tobianus*, or the smaller launce of England. It occasionally, however, reaches a length of about sixteen inches, although it is usually much smaller. On the coast of New England it is very common, and it is recorded that on one occasion, in Provincetown harbor, "they covered the ground from one to two inches deep; and when the water covered the flats, the whole bottom looked like an immense sea of silver."

So far as superficial evidence goes, all the preceding families appear to belong to one sub-order, although a closer study may reveal differences which should cause its disintegration. But there are still other fishes which cannot be well intercalated in the series, and yet of some very little is known. Two alternatives lie before us in the treatment of such forms: (1) we may either "lump" them with others, because we know not what to do with them, and assume that, if they don't show the characters of the major group into which they are thrust, they ought to, or (2) we may isolate them till we do have more knowledge of them. Of the two evils, the latter course appears to be the least prejudicial to the interests of science. Under special sub-ordinal categories, therefore, several groups of uncertain affinities may be considered. They are briefly noticed in the order in which they may be supposed to have diverged from the great Acanthopterygian stock.

Sub-Order IX. — Hypostomides.

A family of doubtful relations, formerly placed in the order Lophobranchii, later near the mailed-cheek Acanthopterygians, and by Prof. Cope associated with the Hemibranchii, has been isolated as an independent order (Hypostomides) by A. Duméril. It is possible that it may have been an early offshoot from a Percesocine or Acanthopterygian stock, and cognate with the Hemibranchii; but too little is known of its anatomy to warrant an authoritative opinion. The sub-operculum is wanting.

Pegasidæ is the name of the only family of the Hypostomides. The body is wide and covered with plates, the snout prolonged, the mouth inferior, and filamentary ventrals developed. The few species are confined to the oriental seas.

Sub-Order X. — Rhegnopteri.

A sub-order named Rhegnopteri has been proposed by Prof. Cope for a family of fishes of doubtful relations. This family has been generally placed among the Acanthopterygii, but by Prof. Jordan it is classed with the Percesoces. The ventral fins are sub-abdominal, the pelvic bones being disconnected from the scapular arch. One spine and five rays are the complement of each ventral; the pectorals are inserted in a peculiar way; the first and the second actinosts bear the main portion; the third is transverse and without any rays, and the fourth carries the free anterior or inferior rays. In other respects, the organization is apparently strikingly like that of the so-called acanthopterygians, and it is only the doubt of its proper place that for

the present justifies the separation of the forms for which it was proposed, from that sub-order.

The Polynemidæ, the only family of Rhegnopteri, are fishes of a more or less sub-fusiform shape, although sometimes compressed, with normal ctenoid scales, and with the head ending in a rather blunt, although protuberant snout; the mouth is well cleft and sub-inferior; there are two dorsals widely separated; the first with seven or eight spines; the last, as well as the anal, oblong; the inferior rays of the pectoral fin are entirely separated from each other, and capable of independent movements, all being flexible forwards; they vary in number from three to fourteen. The species are inhabitants of the tropical seas, and several of those on the Indian coast are of considerable economical importance. The air bladder is extremely diverse, in some it being very largely developed and with appendages, while in other species, very little differing from them in appearance, it is very small or entirely wanting. The large air bladders form a considerable part of the isinglass of India. The largest of the family reach a length of five or six feet, but most species are very much smaller, and the American species are little more than a foot in length, or even less.

Three species visit or occur along the eastern American coast, the *Polynemus plumieri*, *P. octofilis*, and *P. octonemus*.

Sub-Order XI. — Discocephali.

Another sub-order has been constituted for fishes distinguished by the development of a suctorial disk on the upper surface of the head. Only one family — the Echeneididæ — is known.

The Echeneididæ are of great interest, and peculiar in the possession of a sucker-like attachment to the upper surface of the head, which has procured for them the popular name of sucker, suck-fish, and sucking-fish. These have a body quite elongate, wide at the front, and gradually tapering backwards; the head above is very flat, and on a line with the back, and below regularly curved upwards to the margin; the eyes are high up and over-arched by the sucker; the mouth has a moderate oblique cleft; the dorsal fins are two, but the first is so extraordinarily modified, that, to use a Hibernicism, it is not a fin at all; the sucker that surmounts the head is itself nothing but a greatly modified first dorsal whose spines have become cleft, the membranes thickened and leathery, and all subjected to accompanying modifications which result in the remarkable sucker; the true dorsal and the second anal are far behind and of moderate length; the pectorals are high up, and their upper edges near the back; the ventral fins are thoracic and composed of a slender spine imbedded in the skin, and five rays.

The aspect of the fish is so peculiar that an inexperienced observer is very apt to mistake, and, in fact, generally does mistake, the back for the belly and *vice versa*. A glance at our illustration will readily show this.

The species of the family to some extent are parasitic, attaching themselves by means of their suckers to large fishes, especially sharks and sword-fishes, and being in this way borne about, detaching themselves occasionally to obtain food. The tenacity with which they adhere to objects is such that they have been used by some peoples to catch turtles and other fishes.

One of the oldest accounts of their use for fishing was given by Columbus or one

of his companions, and, as rendered in Ogilby's "America," published in 1671, is as follows: —

"Columbus from hence [that is, Cuba], proceeding on further Westward, discover'd a fruitful Coast, verging the Mouth of a River, whose Water runs Boyling into the Sea. Somewhat further he saw very strange Fishes, especially of the *Guaican*, not unlike an Eel, but with an extraordinary great Head, over which hangs a skin like a bag. This Fish is the Natives Fisher, for having a Line or handsom Cord fastned about him, so soon as a Turtel, or any other of his Prey, comes above Water, they give him Line; whereupon the *Guaican*, like an Arrow out of a Bowe, shoots towards the other Fish, and then gathering the Mouth of the Bag on his Head like a Purse-net, holds them so fast that he lets not loose till hal'd up out of the Water."

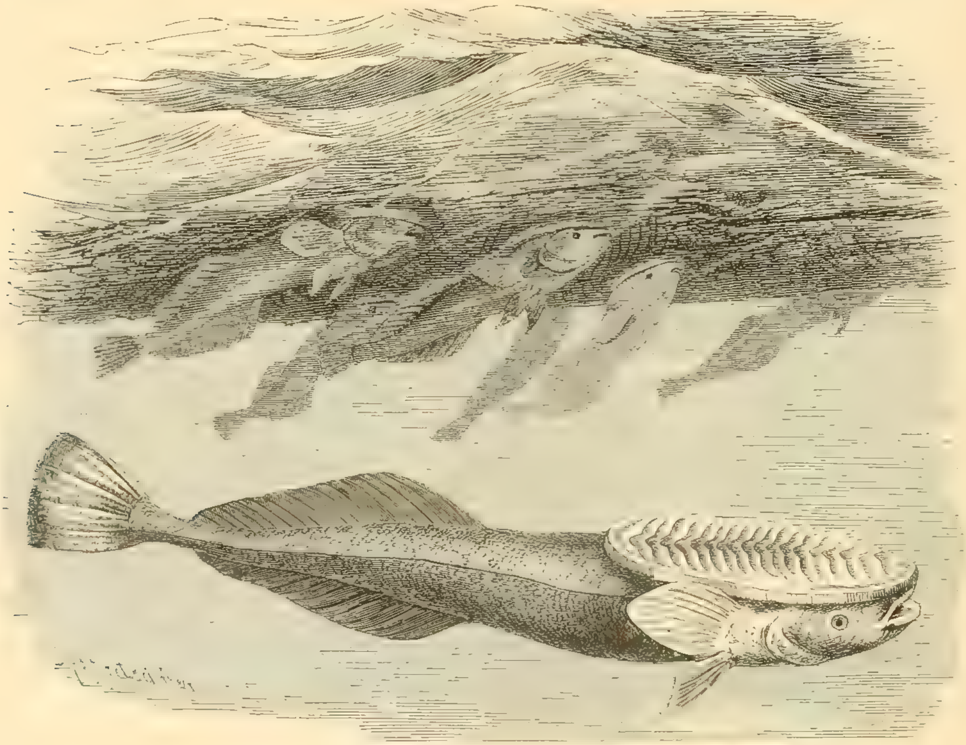


FIG. 149. — *Remora remora*, suck-fish.

The old chronicler had evidently never seen a "Guiacan," but there can be no doubt what was meant, and the name used was that given by the Indians of Cuba to *Echeneis neucrates*. From the time of Columbus we can pass to our immediate present.

In 1884 an account was given of the mode of fishing adopted on the Zanzibar coast by the Africans with the remora. The account is by Mr. Frederick Holmwood, the British consul at Zanzibar. It seems that the Africans fix a ring around the most slender part of the tail, which remains on for an indefinite period, — sometimes for years, — becoming imbedded in the flesh; to this ring the line is attached, and the fish are taken by the Africans on their cruises, which last for a number of days, and slipped loose into the water when wanted; they then swim towards their destined

captives, attach themselves, and are hauled in, securing the fish for their master. The fact of their use in this way had been known long before; but no original account thereof had for a long time appeared. When not in use, the fishes are mostly kept in small canoes or wells of water, and come to the surface on the approach of the fisherman; and they have learned to allow themselves to be taken from the water, and submit to being handled without attempting to plunge or break away. The owners are said to call them with a whistling sound, but whether they obey such a call or not has not been sufficiently verified.

The most common of the Echeneididids are the *Echeneis neucrates*, a slender species with nineteen to twenty-five laminæ in the disk, and *Remora squalipeta* or *remora*, a short fish with eighteen or nineteen laminæ in the disk.

Sub-Order XII. — Tæniosomi.

There are certain forms remarkable for their very compressed form, known popularly as ribbon-fishes, which differ much from other fishes, or, at least, present so few indications of affinity to any one group, that provisionally they may be segregated into a sub-order named Tæniosomi. The typical representatives of the group are destitute of an anal, the dorsal is very long, and its foremost rays elongated and segregated in a distinct portion or nuchal fin, and the caudal is rudimentary or excentrically developed; the ventrals are thoracic. There are two families.

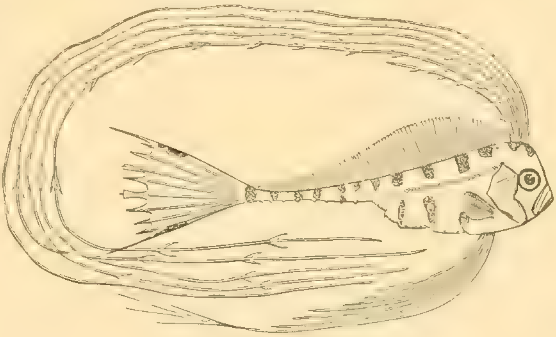


Fig. 150. — Young of *Trachypterus*.

The Trachypteridæ are fishes provided with elongated ventrals of several rays, and destitute of ribs. The species are of uncertain number, but there appear to be two European ones: a northern species, *Trachypterus arcticus*, and one living in the Mediterranean, the *Trachypterus iris*. They are said to attain a length of about ten feet, although the average size must be considerably less. In fact, the largest specimen obtained in the British seas was only seven feet nine inches long. They inhabit deep water, and only appear to voluntarily approach the coast in autumn, when they are at rare intervals taken in herring nets. Most of the specimens examined by ichthyologists have been thrown up on beaches by storms. They are said to somewhat resemble flat-fishes in their movements, and to swim sideways, with one side turned obliquely upwards. Dr. Day records that "the Finland fishermen say that when alive" the northern species is "very fat, and its sides round; but the fat is so liquid and oily that it runs from the body as soon as the fish dies. The Russians at Archangel are said to purchase them for the fat they contain." Deal-fish is a name applied to the *Trachypterus arcticus* in England, and Vaagmer in Iceland and other northern countries.

A remarkable development of the fins is manifested in very young fishes: the rays of the anterior or nuchal portion of the fin are extraordinarily developed, and perhaps two or three times longer than the body; the ventrals are also long, and the caudal large.

The largest of the Tæniosomi are set apart in a distinct family designated REGALECIDÆ. In these the ventrals are represented by single styliform rays, more or less dilated and oar-like at their extremities, and distinct ribs are developed. The species appear to inhabit rather deep water, and some of them grow to a very large size, or at least attain a great length. The species of which most specimens have been seen or cast ashore along the coasts of the Scandinavian peninsula and Great Britain occasionally reaches the length of at least twenty-two feet. But little is known of its habits. One was observed alive, but in a dying condition, about six miles from land, lying on its sides. When approached by a boat, the fish "righted itself, and came with a gentle lateral, undulating motion towards them, showing its crest and a small portion of the head occasionally above water; when it came alongside," a man struck it with a hooked stick, and "it made off with a vigorous and vertical undulating motion, and disappeared as quick as lightning under the surface." Twice the fish escaped its pursuers, but a third attempt enabled them to capture it, two men "putting their arms round the fish," and lifting it into the boat. This specimen was twelve and a quarter feet long.

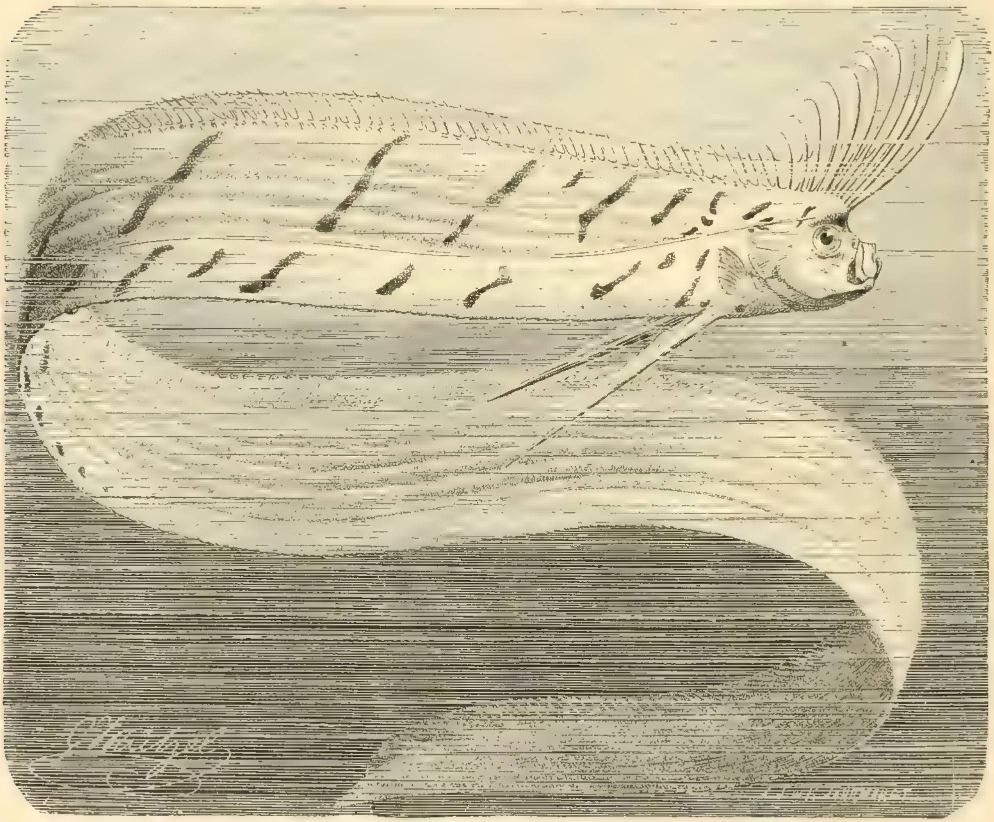


FIG. 151. — *Regalecus banksii*, oar-fish.

The *Regalecus banksii* has received from the English the name of oar-fish, and has also been mingled with the traditions of the sea-serpent, and described as such.

A fish named *Stylophorus chordatus* has generally been referred to the same

family with the preceding, but it apparently belongs to a peculiar one — STYLOPHORIDÆ — and perhaps is not really related to the typical Tæniosomi.

SUB-ORDER XIII. — XENOPTERYGII.

There are certain fishes distinguished by the development of a suctorial apparatus on the breast of a very complicated nature. They have been generally approximated to the Cyclopteridæ and Liparididæ, simply because they had the suctorial apparatus, and the other fishes had likewise sucking appendages. But the adaptation for similar purposes has been effected in the group now under consideration — the GOBIESOCIDÆ — in a very different way from that exemplified in the lump-suckers and their relations, as has been well shown by Dr. Günther. The suctorial disk is developed chiefly from the skin of the breast, and only formed at its front by the ventrals, which are wide apart. There are no spines in any of the fins, and thus it has not even the technical characteristics of the true Acanthopterygians. Doubtless the parentage of the stock is to be looked for in that great sub-order; but the divergence of the known forms has been so great that at present it cannot be certainly predicated whereabouts to find it. The distinction of the group is sanctioned by modifications of the skull, especially the reduction of the palatal arcade, and the loss of the suborbital ring, as well as by a peculiar development of the several elements of the shoulder girdle.

The Gobiesocidæ are mostly fishes having an oblong or elongate coniform body destitute of scales, a depressed head, a single posterior dorsal, an anal more or less opposite, pectorals generally extending downwards along their bases around the front of the suctorial disk, and the suctorial disk entire, or divided into two portions by a transverse fold of the skin.

Almost all the species are small fishes, most numerous in the tropical or warm temperate seas, chiefly living between tide-marks or in shallow water, and generally adherent to stones or rocks by means of the suctorial disk. Several species occur along the American coasts, the largest and most common being the *Gobiesox* or *Caularchus reticulatus* of California. That species reaches a length of about six inches.

SUB-ORDER XIV. — ANACANTHINI.

An order or sub-order has been almost universally recognized for the common codfishes, and in the same group have been almost universally approximated forms which certainly have considerable superficial resemblance to those fishes, but which anatomy shows to be much less closely allied than has been supposed. The chief distinctive characters of the sub-order (for at most it is nothing more) is the absence of any fenestra or hole in the hypercoracoid or, as it is often called, scapular bone, and its representation only by the inter-space between the hypercoracoid and hypocoracoid. Several families belong to this sub-order, thus defined, and one of them is of very great economical importance. This is the family Gadidæ.

The GADIDÆ are fishes with the caudal portion of the body coniform behind and with the caudal rays precurrent above and below, a sub-median anus, moderate suborbital bones, mouth terminal, or nearly so, and thoracic ventrals. The dorsal fins are variously developed, and the anal, also diversiform, is confined mostly to the posterior half of the length. It will be most convenient to bring them under groups or subfamilies.

The sub-family of the typical cods, or Gadinæ, is distinguished by the development of three dorsals and two anals, and of complete but moderate ventrals. By far the most important members of the family belong to it, such as the cod-fish, — specifically so-called, — the haddock, the pollock, and the whiting.

The common cod-fish (*Gadus morrhua*) is not only the most important species of the family, but the most important of fishes to man. It may be briefly defined as a gadine with the lower jaw shutting within the upper, a well-developed barbel, and the anus below the second dorsal fin; the chief shoulder-girdle bone is lamelliform. Cod or cod-fish is the name by which it is universally known to the English-speaking peoples, but it has also a number of synonyms, either of a local nature or applicable to different stages or conditions.

Sometimes the species attains a very large size, considerably exceeding one hundred pounds in weight. One taken on George's Bank in 1838, after having been eviscerated, weighed one hundred and thirty-six pounds. Another, taken in 1873 by a lady of St. Louis, on a fishing excursion at Eastern Point, weighed one hundred and thirty pounds. Captain Atwood, a very experienced and educated fisherman, once saw one which weighed as much as one hundred and sixty pounds; the fish was not much longer than an ordinary fish weighing seventy-five pounds, but was very thick.

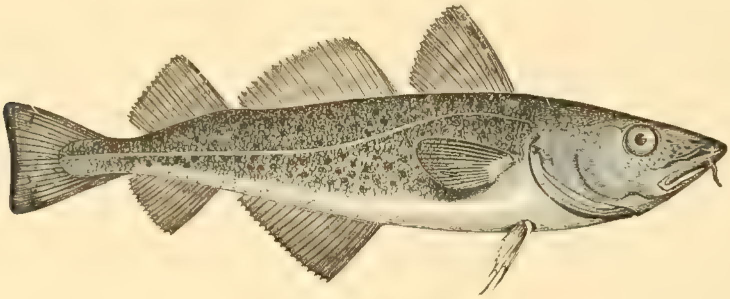


FIG. 152. — *Gadus morrhua*, cod.

Such fishes are, however, entirely exceptional. Captain Atwood has informed us that on the coast of Cape Cod he has never seen a male cod-fish, with the exception just noticed, which weighed more than sixty pounds. In regard to the general size of the cod, the same authority remarks that it differs very widely in different localities. When taken on the Grand Bank, it usually requires from thirty to forty to make a quintal when dried. Those caught in the Gulf of St. Lawrence with hand lines are smaller, requiring seventy to eighty per quintal. In the same locality, however, cod are caught with trawl lines requiring only twenty to twenty-five to make a quintal; while on the coast of Labrador they are all small, and it requires about one hundred to one hundred and ten for a quintal. The average weight of fish taken about Cape Cod is in the neighborhood of ten pounds.

The name *Gadus* and cod, if the conjectures of Mr. Brevoort can be implicitly accepted, are words which have had a common origin; for it is asserted that the word *gadus* comes from a Sanskrit root, cod or gad, meaning a rod; "we find this root in English in 'goad,' and, perhaps, in cat-o'-nine-tails." Further, the name cod (having the same form among the Anglo-Saxons) is cognate with the word "gad, or goad, a rod." To substantiate the probability of these etymologies, it is affirmed, as a well-known fact, that the Germans know the fish as "stock-fisch, from stock, a stick."

Etymology is a dangerous tool to handle, although a very valuable one, and authors are not agreed upon the subject. Skeat, for example, remarks that he supposes that "the word cod must be the same as the middle English codde or cod, a husk, bag, bolster; though the resemblance of the fish to a bolster is but fanciful. It is obvious that Shakespeare knew nothing of the Linnæan name *Gadus* (Greek, γάδος), nor is the derivation of *cod* from *gadus* at all satisfactory." We leave the choice of the etymologies to the reader, simply reiterating the dictum of Mr. Skeat that "the resemblance of the fish to a bolster is but fanciful," with the hint that the cod must have been known before the bolster. Some vagaries of etymologists as to the names of fishes have already been referred to (*e. g.*, see John Dory, p. 208).

The home of the cod-fish is in the cold waters of the entire northern hemisphere, and far into the arctic circle. The authority of Mr. Goode shall guide us for details. "In the western Atlantic, the species occurs in the winter in considerable abundance as far south as the mouth of the Chesapeake Bay, latitude 37°, and stragglers have been observed about Ocracoke Inlet. The southern limits of the species may safely be considered to be Cape Hatteras, in latitude 35° 10′. Along the coast of the Middle States, New England, and British North America, and upon all the off-shore banks of this region, cod are found usually in great abundance, during part of the year, at least. They have been observed also in the Gulf of Boothia, latitude 70° to 75°, and in the southeastern part of Baffin's Land to the northward of Cumberland Sound, and it is more than probable that they occur in the waters of the Arctic Sea to the north of the American continent, or away around to Bering's Straits." Its range in the North Pacific has not been equally well ascertained. It appears, however, "to occur in the same abundance on all the off-shore banks of this region, and also close to the coasts to the north of the Straits of Fuca. According to Jordan, there is said to be a cod-bank outside of the mouth of the Columbia, but the species, at present, is of no economical importance south of Alaska."

The ocean banks of moderate depths are the favorite resorts of the cod, but it is by no means confined to those localities. The fish, indeed, occasionally enters into fresh, or at least brackish, water. According to Canadian authorities, it is found "well up the estuary of the Saint Lawrence, though how far up is not definitely stated, probably not beyond the limits of brackish water." Even as far south as the Delaware River it has been known to enter the stream. Dr. C. C. Abbott records that in January, 1876, "a healthy, strong, active cod-fish, weighing nearly four pounds, was taken in a draw-net in the Delaware River, near Trenton, New Jersey; the stomach of the fish showed that it had been in river-water several days. Many of them had been taken about Philadelphia between 1856 and 1869."

The cod ranks among the most voracious of ordinary fishes; and almost everything that is eatable, and some that is not, may find its way into its capacious maw. Years ago, before naturalists had the facilities that the dredge now affords, cods' stomachs were the favorite resort for rare shells, and some species had never been obtained otherwise than through such a medium, while many filled the cabinet that would not otherwise have been represented. In the words of Mr. Goode, "cod-fish swallow bivalve fish of the largest size, like the great sea-clams, which are a favorite article of food on certain portions of the coast;" further, "these shells are 'nested,' the smaller inside of the larger, sometimes six or seven in a set, having been packed together in this compact manner in the stomachs of the cod-fish after the soft parts have been digested out. Some of them had shreds of the muscles remaining in them,

and were quite fresh, having evidently been but recently ejected by the fish." Even banks of dead shells have been found in various regions, which are supposed to be the remains of molluscs taken by the cod. Shell-fishes, however, form probably but the smaller portion of its diet, and fishes of its own class contribute materially to its food, — such as the herring family, the capelin, etc.

The cod-fish, in its mode of reproduction, exhibits some interesting peculiarities. It does not come on the coast to spawn, as was once supposed, but its eggs are deposited in mid-sea, and float to the surface, although it does really, in many cases, approach the land to do so. Prof. G. O. Sars, who has discovered its peculiarities, "found cod at a distance of twenty to thirty Norwegian miles from the shore, and at a depth of from one hundred to one hundred and fifty fathoms." The eggs thus confided to the mercy of the waves are very numerous; as many as 9,100,000 have been calculated in a seventy-five-pound fish. "When the eggs are first seen in the fish, they are so small as to be hardly distinguishable; but they continue to increase in size until maturity, and after impregnation have a diameter depending upon the size of the parent, varying from one nineteenth to one seventeenth of an inch. A five to eight pound fish has eggs of the smaller size, while a twenty-five pound one has them between an

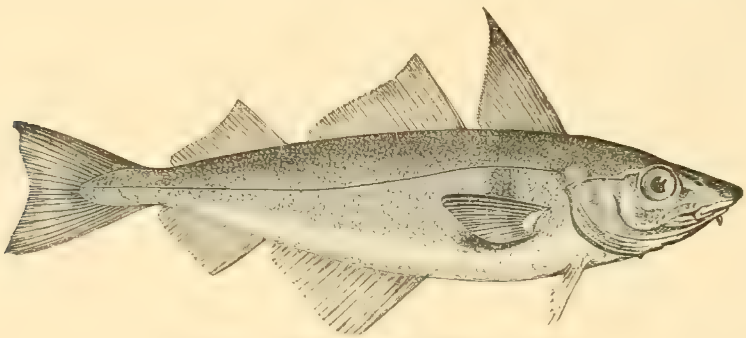


FIG. 153. — *Melanogrammus æglefinus*, haddock.

eighteenth and a seventeenth." There are about 190,000 eggs of the smaller size to a pound avoirdupois. They are matured and ejected from September to November.

The haddock, *Melanogrammus æglefinus*, is another important member of the subfamily Gadinæ, and may be distinguished from the cod by the smaller mouth, the black lateral line, and the swollen proscapula or chief element of the shoulder girdle. Its fins are also more angulate or pointed than in the cod. Its average size is about three or four pounds; one of seventeen pounds is the largest that has been recorded, but a number of twelve-pound fishes, and still more in proportion for the lower figures, have been obtained. The range of the haddock is much more limited than that of the cod-fish; it is confined to the North Atlantic, and extends less to the northward than the cod, although about equally far southward. Within its more limited range it is found generally upon the same fishing grounds. In winter and spring, fishes are taken "in Fisher's Island Sound and outside of Fisher's Island, on the coast of eastern Connecticut; and also in great quantities on Nantucket Shoals, by the smacks, and are carried thence with cod to the New York market. In 1871 it was estimated that the catch of haddock here was nearly equal to that of cod, although the latter usually predominated. They abound north of Cape Cod, in the Gulf of Maine, and in the Bay of Fundy, in the Basin of Minas, on the coast of Nova Scotia, in the Gulf of

St. Lawrence, and in the Bay of Chaleur." In the eastern Atlantic its range is comparatively more extended, and more nearly coincident with that of the cod. According to Mr. Goode, "remarkable variations in the abundance of this fish are upon record; at certain times they have been exceedingly rare, at others abundant in the extreme. They appear to be much more gregarious than the cod-fish, and to swim together in large schools from place to place."

As to its food, there is little difference between the haddock and the cod. Most sea animals are acceptable, and Prof. Verrill has said that "a complete list of the animals devoured by the haddock would doubtless include all the molluscs belonging to the fauna of New England." One difference between the haddock and the cod, however, is stated to be that while "salted menhaden is a favorite bait for haddock," it is "not desirable for cod;" but "both cod and haddock will readily take stale clams, which are much better for bait than fresh ones."

The haddock spawns on "rocky bottoms in the German Ocean in February and early March, at a depth of twenty-two to twenty-five fathoms," and about Cape Ann "begins about the middle of April, and continues during nearly three months, the height of the season being in May," according to Mr. Earll. The haddock being smaller than the cod, the number of its eggs is less. In one of nearly ten pounds, 1,839,581 eggs were calculated, while one of two pounds and a half yielded only about 169,050.

The haddock is held in considerable favor as a food fish, and the demand seems to have increased of late years. "It is especially desirable for boiling, or for making chowders, and is a great favorite in Boston, while in Philadelphia enormous quantities are yearly consumed." It is also cured by smoking in the "Scotch method," which has been introduced into the United States. "Finnan Haddies are manufactured in enormous quantities in Portland and Boston. At Provincetown, a haddock salted and dried after being split is called by the name 'skulljoe,' or 'scoodlo.'"

Another important Gadid is the pollock, *Pollachius virens*. This has the lower jaw projecting beyond the upper and the barbel is small, or entirely absent; the color is greenish-brown above, even inclining to blackish; the sides and inferior region are of a silvery hue, and the lateral line whitish. Pollock is the chief name by which it known in America. It has a very large number of appelatives in England; nearly one hundred have been enumerated, but the one most in use appears to be coal-fish. It is intermediate in size between the haddock and cod-fish, the average being probably not far from ten to twelve pounds, but individuals of twenty and even of thirty pounds are by no means uncommon. Its geographical range is peculiar, extending northward nearly as far as the cod, and southward it is said to enter the Mediterranean, but is very rare in that sea. It also rarely enters the Baltic. It is confined to the Atlantic, but represented by a related form in the North Pacific. In the words of Mr. Goode, "unlike the cod and haddock, the pollock is, to a great extent, a surface-swimming species. The fishes of this species congregate together in large schools, roaming from place to place in search of food. To a certain extent they feed at the bottom, like cod, but they are more often seen at the surface of the water, where they prey upon young fish of all kinds." They are also much more prone to approach close to the shore, and are frequently taken from the wharves and the shores generally.

The pollock's reproductive habits are essentially similar to those of the cod-fish. The eggs are matured in October or November, and, consigned to the waves, float to

the surface as do those of cod-fish. The young more frequently are to be found under the umbrellas or disks of large jelly-fish. Their growth appears to be more rapid than that of the cod, "since the young fish are so much more voracious, but we have no means of determining the length of time required for them to attain maturity."

In the opinion of Mr. Goode, "the pollock is one of those species whose value as an article of food is very much underestimated. Many persons who have investigated

FIG. 154.—*a*, *Melanogrammus æglefinus*, haddock; *b*, *Merlangus vulgaris*, whiting; *c*, *Gadus morrhua*, cod.

the subject accurately prefer salted pollock to salted cod-fish, although the flesh is not so white." It is, however, "for use in the fresh state" that it "deserves the highest commendation."

The whiting, *Merlangus vulgaris*, is another species of the genus, held in high estimation in England and other parts of Europe, but not known along the American coast. The upper jaw is the longer, but it has no barbel.

The whiting is said to attain a weight sometimes of eight pounds, but a fish of two to three pounds is considered to be a very fine one. Its range is more restricted

to the northward, than that of the cod, haddock, or pollock, and it does not extend across the ocean. We are informed by Dr. Day that on the British coasts, "it appears in the spring in large shoals, and though delighting in sandy bays, where young fish abound, it seems to be shy, and mostly keeps from half a mile to three miles from the shore, in springtime hanging about the more distant rocks," and "even during summer months, it often keeps two or three miles from the coast." It is believed to be very susceptible to the influence of cold. Its flesh is highly esteemed, according to Dr. Day, "more so, perhaps, than any other species of the genus, being very easy of digestion." It is often caught by "whiffing, when it gives good sport, especially during rough weather;" the best time is "early in the morning, or in the evening; it will rise, by moonlight, into mid-water after its prey."

There are a number of fishes closely related to the cod, haddock, and pollock, and belonging to the same sub-family, Gadinæ. The most noteworthy of the American species are the tom-cods; the eastern species being the *Microgadus tomcod;* the Pacific coast species, the *M. proximus.* These are of small size, the average being less than a foot, and during the summer season they come close into shore, and are frequently taken from the wharves. They are quite savory, but of little economical importance compared with their larger relatives.

Several other species of this family are of scientific interest as well as economic importance. The dorsal fins are reduced to two, the first being rather short, and the second very long and without any division whatever, and the anal is also entire; a peculiar character is manifested in the ventral fins, which are extremely narrow and bifurcated or produced into two long slender filaments, the other rays being very rudimentary, and not apparent externally. The sub-family name Phycinæ has been used for them.

Three species are common along the eastern American coast, *Phycis chuss*, *Phycis tenuis*, and *Phycis regius.* The first two are of some economical importance, especially on account of their air-bladders or sounds; they are generally known as hakes, the true hake (*Merlucius*) being called silver-hake or whiting. The corresponding species of England, *Phycis blennioides*, is sometimes designated as hake's dame, and is also named fork-beard.

The accompanying illustration of an Australian and New Zealand species (*Macrurus australis*) will give an idea of the form.

A fresh-water Gadid, the burbot, is the type of another sub-family, the Lotinæ, distinguished by the development of two dorsals, a first short one, and a second long fin; the anal is also elongate, and the ventrals are like those of the Gadinæ. Several salt-water species, constituting the genus *Molva*, belong to it, as well as the burbot.

The burbot, *Lota maculosa*, *L. lota*, is the only exclusively fresh-water Gadid, and is common to the northern portions of both Europe and America. In America it is more generally known as the cusk and eel-pout, but in Alaska as the Losh (a corruption of Loche, common among the French Canadians). In Alaska it occasionally attains a length of six feet and a weight of sixty pounds, according to Mr. Dall; but such a size is entirely exceptional. The average size of mature individuals is in the neighborhood of five pounds.

The burbot is an inhabitant of the lakes and rivers of central and northern Europe, and in America extends southwards into the Susquehanna River in the east, and Missouri in the central regions, but is more common as well as larger northwards.

Like its kind, the burbot is a voracious feeder, and few animals living in the same waters are exempt from its attacks; even stones have been repeatedly found in its stomach. The hours of darkness are those in which it is most active in search of prey, and when the fishermen chiefly seek for it.

The spawning season appears to be mid-winter to early spring. The eggs are moderately numerous, an average size female maturing about 160,000 to 180,000 eggs, but in large individuals they are more numerous. The eggs readily separate from each other, and are deposited on the bottom. The young are mostly hatched in about three or four weeks, according to temperature. At first they move but little, and in a circle; later, and when fully developed, they swim by quick movements of their pectoral fins.

Difference of opinion prevails as to the edible qualities of the burbot. It is

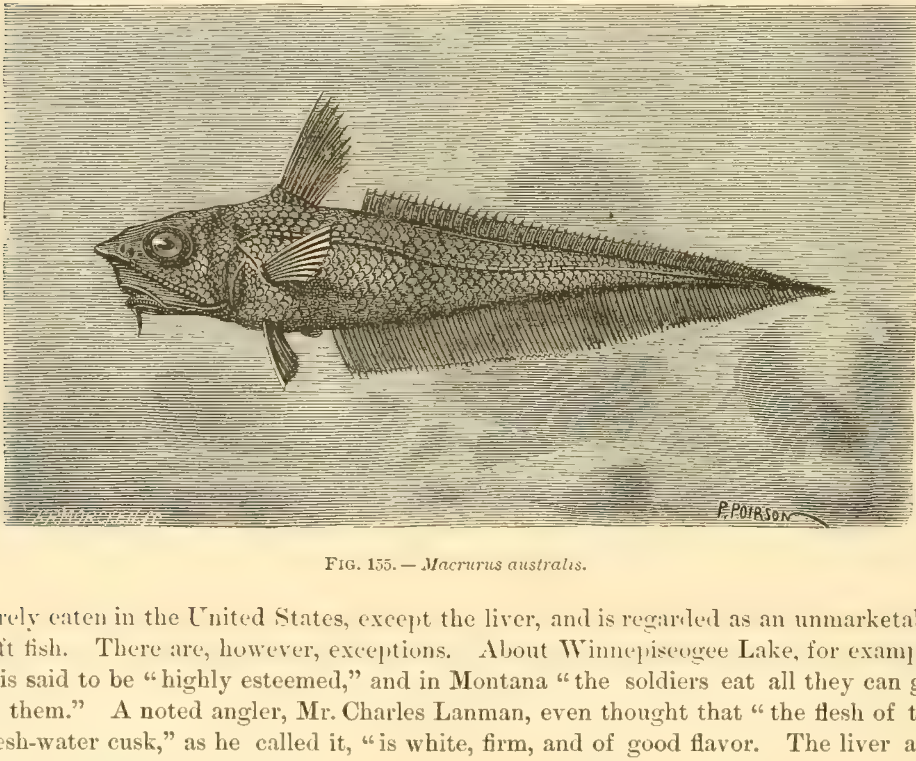


FIG. 155. — *Macrurus australis.*

rarely eaten in the United States, except the liver, and is regarded as an unmarketable soft fish. There are, however, exceptions. About Winnepiseogee Lake, for example, it is said to be "highly esteemed," and in Montana "the soldiers eat all they can get of them." A noted angler, Mr. Charles Lanman, even thought that "the flesh of the fresh-water cusk," as he called it, "is white, firm, and of good flavor. The liver and roe are considered delicious."

A peculiar use has been found for the burbot in Siberia. According to Mr. Dall, the skins are used as a substitute for glass in windows.

A family (MERLUCIIDÆ) closely related to the Gadidæ is represented by fishes of an elongated, compact, and powerful form, covered with regular bright scales, with a head above excavated by a median cavity, bounded behind by ridges diverging from the supra-occipital crest. There are two dorsal fins — the first complete and short, the second long and sinuated. The anal resembles the second dorsal. The pectoral fins are long, and rather narrow; the ventral fins thoracic and complete. Only one genus of this family has been recognized. The species are distributed quite generally in the temperate and moderately cool seas, both in the northern and southern hemispheres.

The popular name current in England is hake, but in the United States the prefix 'silver' is generally added, to distinguish it from the species of *Phycis*, which are known in the New England states as hakes. It is also frequently called whiting, New England whiting, or Old England hake. The species are all very voracious, and are found in water of moderate depth.

The common English species is *Merlucius vulgaris;* that of the eastern American coast, *Merlucius bilinearis.* The American is at once distinguished from the European species by the larger scales. It ranges from about New York to the Gulf of St. Lawrence, where it is common, especially in the Bay of Chaleur; but it has rarely been observed as far north as the Straits of Belle Isle. It has also been taken as far south as latitude 36° or 37°, but at greater depths than in the north.

A large group of fishes related to the cod-fishes was, for a long time, known through few and rare species, but the deep-sea explorations of recent years have brought to light many members of the same group, and have revealed the fact that the long-known species were rare simply because they were wanderers from their home in the deep, and that they and their kindred are among the most common of the deep-sea fishes. MACRURIDÆ is a family name conferred on them. They have an elongated body, tapering from the head into a long, very attenuated tail, and the scales are generally rough or spiny; the head is large, and most have a produced and ridged snout, and cheeks covered by enlarged sub-orbital bones; a first short and somewhat elevated fin exists near the nape, and generally has the first ray spine-like and prickly; a long second dorsal, and still larger anal, are confluent with the generally undistinguishable caudal; the pectorals are normally developed, as are also the ventrals, which are in advance of the former. Though generally much unlike the cod-fish in appearance, their anatomy proves that they are closely related, and there are forms which greatly narrow the gap between the typical representatives of the two families. The longest known species are the *Macrurus rupestris* and *Coryphænoides norvegicus* of the sub-arctic and deep seas. The *Coryphænoides* is found occasionally (very rarely) in British seas, but does not appear to have received an English name. In Norway, where it is oftener taken, it is called Berg-lax.

SUB-ORDER XV. — HETEROSOMATA.

A characteristic is exhibited in some fishes whereby they depart from all other vertebrates and manifest an exception to a general rule, viz.: that the sides are alike, or, in other words, that vertebrates are "bilaterally symmetrical." It is true that asymmetry is seen in most of the viscera of vertebrates generally, and even in some of the head-bones, especially about the nose of the toothed cetaceans, but the asymmetry is entirely concealed or not conspicuous externally. In a number of fishes, however, the want of bilateral symmetry is very striking; the body is very compressed, and one side, as a rule, is whitish or uncolored, while the other is dark; further, the eyes are both on the colored side. The fishes so marked are popularly known as flat fishes. They are prone to lie on the bottom, flat on the light side, and with the dark side, much the color of the ground, upwards, and the eyes are then both seen and seeing in one direction. Such is the case with the old and all but the very young. But a remarkable history is that of the flat-fishes. When they are born, and for some time afterwards, they are symmetrical fishes, with an eye on each side, and may be seen swimming in mid-water, nearly straight, but with a tendency to lean

to one side. The tendency to do so becomes more and more marked, but the eye of the inclined side disdains to look downwards, and strives to turn upwards; the endeavor accomplishes its purpose, and finally it becomes settled upwards, and the contiguous parts of the skull are twisted round to correspond.

The typical flat-fishes, constituting the family PLEURONECTIDÆ, are all much compressed, with the contour more or less rhombiform; the head is angulated at the front, and generally the lower jaw is produced; the preoperculum is quite distinguishable externally, and the mouth is oblique and rectilinear; the lateral line is distinct. To it belong numerous species; there are on the eastern coast of the United States twenty-two species, and on the western coast twenty-four species.

The most important representative of the family is the halibut (*Hippoglossus vulgaris*); it is distinguished from all other species by its more elongated and much thicker body, and its head is still thicker in proportion. The caudal fin is also emarginate. It is the least aberrant of all the flat fishes, save one, of the American waters. It is found in the northern Atlantic, as well as northern Pacific, very near the shores in shallow water, and upon the off-shore banks and the edges of the continental slope down to a depth of two hundred to two hundred and fifty fathoms or more.

The halibut is emphatically a cold-water species. "That it ranges nine or ten degrees farther south on the American than on the European coast, is quite in accordance with the general law of the distribution of fish life in the Atlantic; indeed, it is only in winter that halibut are known to approach the shore to the south of Cape Cod, and it is safe to say that the temperature of the water in which they are at present most frequently taken is never, or rarely, higher than 45°, and seldom higher than 35°, and often in the neighborhood of 32°. Its geographic range corresponds closely to that of the cod-fish, with which it is almost invariably associated, though the cod is less dependent upon the presence of very cold water, and in the western Atlantic is found four or five degrees — in the eastern Atlantic at least two — nearer the equator, while the range of the two species to the north is probably, though not certainly, known to be limited relatively in about the same degree. In the same manner the halibut appears to extend its wanderings further out to sea, and in deeper and colder water than the cod. Although observations on this point have necessarily been imperfect, it seems to be a fact that, while cod are very rarely found upon the edge of the continental slope of North America, beyond the two hundred and fifty fathom line, halibut are present there in abundance."

The name halibut was formerly supposed to be derived from *holy* and *but*, that is, a sacred or holy flat-fish; but why it should have been called "holy" was a matter of wonder, and the suspicion arose that something must be wrong in the etymology. By far the most probable conjecture is, that it is descriptive of habitat, a word meaning a *hole flounder*, or flat-fish living in holes or deep places; this would be really appropriate as well as in accordance with usage in several languages.

In Sweden it is called hällefisk or hålleflundra, which means a hole-fish or hole flounder; that is a deep-sea fish or deep-sea flounder.

The halibut is the largest by odds of all the Pleuronectidæ, and ranks indeed fourth in size among the teleost fishes of the United States. There is, however, a considerable difference between the sexes. The male, it is claimed, rarely exceeds fifty pounds, and is ordinarily in poor condition and less desirable for food. The average size of the full-grown female is somewhere between one hundred and one hun-

dred and fifty pounds though sometimes much heavier. Indeed, one has been recorded by a celebrated Swedish ichthyologist, Nilsson, which weighed 720 pounds, but the most experienced halibut fishers have never met with such giants, and Captain Atwood doubted the truth of a published account of one which weighed over 600 pounds; and the largest that he had seen were two in 1879; one weighing 359 pounds, and the other 401 pounds. A fish weighing 350 pounds is between seven and eight feet long, and nearly four feet in width. Small ones are very rarely met with. The very large ones are coarse as food, and a fat female of 80 pounds is considered by good judges to be in the highest state of perfection; males are not, however, so highly esteemed. Small halibut weighing from ten to twenty pounds are often known as chicken-halibut, and such are the most esteemed and command a high price.

According to Mr. Goode, "the history of the halibut fishery has been a peculiar one. At the beginning of the present century, these fish were exceedingly abundant in Massachusetts Bay. From 1830 to 1850, and even later, they were extremely abundant on George's Banks; since 1850 they have partially disappeared from this region, and the fishermen have since been following them to other banks, and, since 1874, out into deeper and deeper water, and the fisheries are now carried on almost exclusively in the gullies between the off-shore banks and on the outer edges of the banks, in water one hundred to three hundred and fifty fathoms in depth."

The halibut, with its large mouth, is naturally a voracious fish, and probably would disdain few objects in the way of fresh meat it would come across. It is said, however, to feed more especially upon crabs and molluscs in addition to fish. These fish "they waylay, lying upon the bottom, invisible by reason of their flat bodies, colored to correspond with the general color of the sand or mud upon which they rest. When in pursuit of their prey they are active, and often come quite to the surface, especially when in summer they follow the capelin to the shoal water near the land. They feed upon skates, cod, haddock, menhaden, mackerel, herring, lobsters, flounders, sculpins, grenadiers, turbot, Norway haddock, bank-clams, and anything else that is eatable and can be found in the same waters." Frequently halibut may be seen chasing flat-fish over the bottom of the water. About Cape Sable their favorite food seems to be haddock and cusk. A very singular mode of attacking a cod has been recorded by Captain Collins, an experienced fisherman and good observer. They often kill their prey by blows of the tail, a fact which is quite novel and interesting. He has described an instance which occurred on a voyage home from Sable Island in 1877: "The man at the wheel sang out that he saw a halibut flapping its tail about a quarter of a mile off our starboard quarter. I looked through the spy-glass, and his statement was soon verified by the second appearance of the tail. We hove out a dory, and two men went with her, taking with them a pair of gaff-hooks. They soon returned, bringing not only the halibut, which was a fine one of about seventy pounds' weight, but a small cod-fish which it had been trying to kill by striking it with its tail. The cod-fish was quite exhausted by the repeated blows, and did not attempt to escape after his enemy had been captured. The halibut was so completely engaged in the pursuit of the cod-fish, that it paid no attention to the dory, and was easily captured."

The females become heavy with roe near the middle of the year, and about July and August are ready to spawn, although "some fishermen say that they spawn at Christmas" or "in the month of January, when they are on the shoals." The roe of a large halibut which weighed three hundred and fifty-six pounds weighed forty-four

pounds, and indeed the "ovaries of a large fish are too heavy to be lifted by a man without considerable exertion, being often two feet or more in length." A portion of the roe, "representing a fair average of the eggs, was weighed and found to contain 2,185 eggs," and the entire number would be 2,182,773.

The turbot, *Psetta maxima*, is distinguished by its wide body, the absence of any scales, and the development of simple tubercles upon the body, and the color, which is sandy-brown with dark spots and blotches on the colored side. The fish is of large size, being next in that respect, among the English flat-fishes, to the halibut. The largest authentic one appears to have been of seventy pounds weight; another of forty-four and a half pounds was taken in Ireland; Parnell was informed of one which weighed one hundred and ninety pounds, but this, doubtless, was a halibut, which sometimes bears the same name in Scotland.

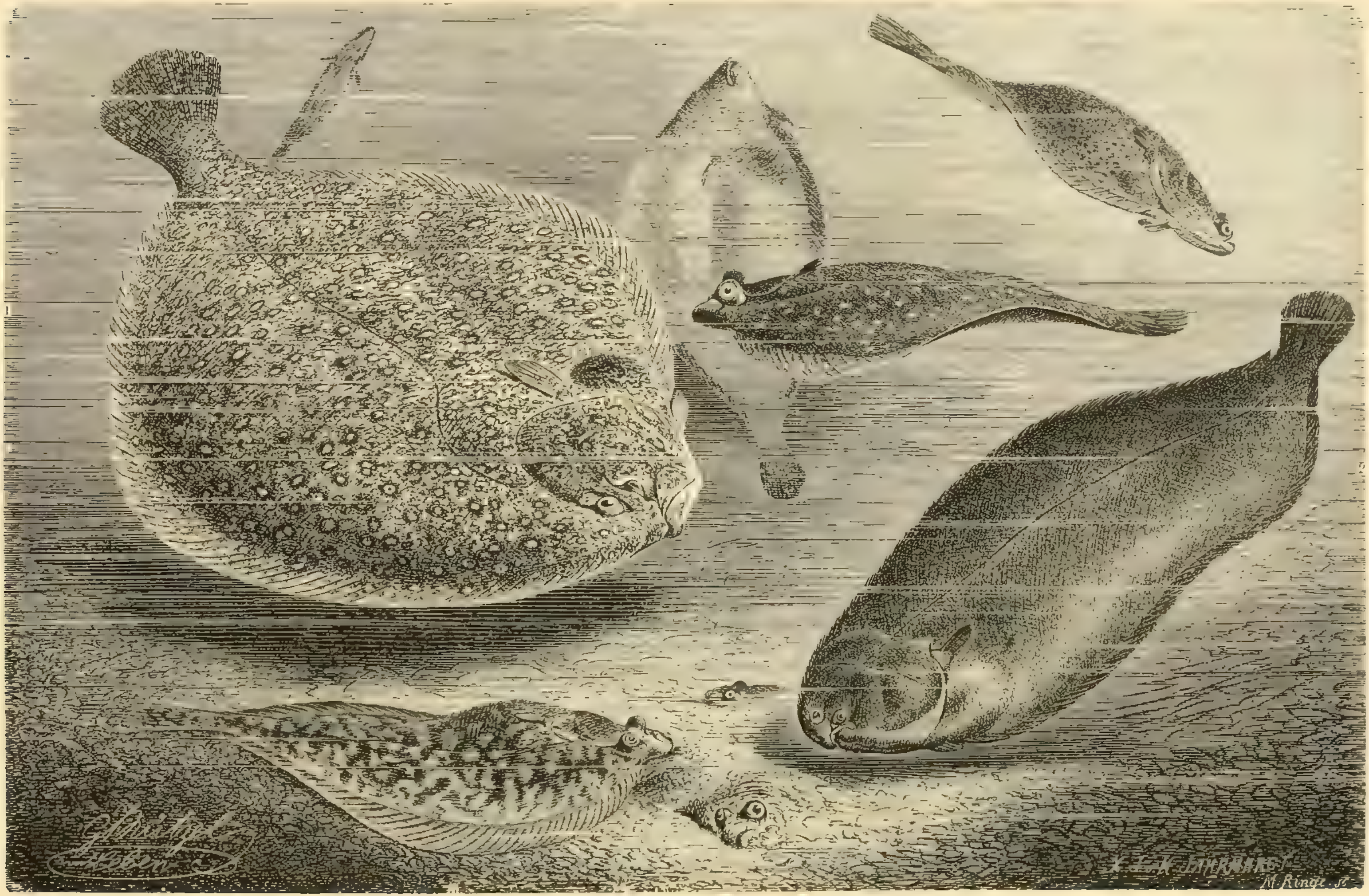
The range of the turbot is almost throughout the European seas, extending from the Mediterranean to the coast of Scandinavia. It is found on sandy and muddy bottoms in water of moderate depth, and even in shallow water. It is erratic in its movements, however, and in winter generally retires into deeper water. Its diet appears to consist of crabs and their like, but it also feeds upon star-fishes, sea-urchins, and the eggs of fishes, and fishes themselves of its own class.

The reproductive organs become functionally developed in spring and summer. The female has a large number of eggs of very small size; in one of twenty-three pounds weight Buckland found the roe weighing five pounds nine ounces, and with about 14,311,200 eggs. The young appear to retain their symmetrical condition for a longer period than most of its kind, but this may be due to the larger size of the fish itself. Dr. Day mentioned one of one and a half inches long, in which the eye was still in transit from one side to the other. In the Southport aquarium the young of two and a half years past had grown to a weight of ten pounds, and in two years more the same fishes had further augmented to twenty pounds, or an average annual increase of four and a half pounds each.

The turbot is the prince of its tribe, so far, at least, as its relations to man are concerned. Its reputation, however, is probably to some extent the result of fashion, and it is not probable that it really has points of excellence much above two or three American species of the family. It is generally boiled for the table, and lemon juice is rubbed over to preserve its whiteness.

The turbot has been repeatedly stated to be found along the American coast, but all such statements have been baseless. Its nearest American relative is the *Lophopsetta maculata*, a fish of no value for food or anything else, and known by such suggestive names as window-pane and daylight, it being so thin as to be almost transparent. But it is sometimes called spotted-turbot. In the United States, however, the name turbot is chiefly applied to flat-fishes of the genera *Paralichthys* and *Reinhardtius*.

The common plaice of Europe (*Pleuronectes platessa*) is a fish with teeth like the palings of a fence, compressed, blunt, and close together; the body is covered with small, imbricated, cycloid scales, and there are still smaller ones on the cheeks and opercular bones; the lateral line is nearly straight. The color of the dark side is brownish, suffused with reddish and mottled with orange or yellowish spots nearly as large as the eyes. One has been found of fifteen pounds weight, but the general size is less than two pounds. It ranges along the Atlantic coast of Europe, but is very rare in the Mediterranean. It is found upon both sandy, muddy, and rocky bottoms, and in waters of moderate depth. "When disturbed, it will shoot away



FLAT FISHES.
1. *Psetta maxima*, turbot ; 2. *Solea solea*, sole ; 3. *Pleuronectes platessa*, plaice.

suddenly for a short distance, and can work itself rapidly into the sand, where it lies concealed, with only its eyes being apparent." Its food consists, to a large extent, of shell-fish, but it is limited by the small size of the mouth. The breeding season is "about February or March." The eggs are moderately numerous, 144,600 having been found in a fish weighing four pounds fifteen ounces. In the words of Dr. Day, "the opinion was formerly entertained that the plaice is descended from a shrimp, and Dr. Deslandes investigated the subject. He first placed some of the shrimps in a vessel of salt water, and after twelve or thirteen days he discovered eight or nine young plaice. The next year he placed some of these fish in two different salt-water receptacles, and to one lot he added a few of the shrimps, not so to the other. Both lots spawned, but it was only where the shrimps were that any young were produced. On examining the shrimps, he discovered the ova attached to the under surface of these crustaceans, and he felt persuaded that their maternal care is a necessity for bringing forth the fry." Such was the way our forefathers reasoned and experimented!

The plaice is esteemed as a table fish, and large numbers are brought to the markets, upwards of three millions being annually consumed in London. Its quality is said to depend upon "the nature of the ground on which it is captured: when from sand, it is firm and sweet; if from muddy, the reverse." They are chiefly taken by "lines or beam trawls."

Several near relatives of the plaice inhabit American waters, the nearest on the Atlantic coast being the *Pleuronectes glaber*, which is called fool-fish at Salem, because they are easily decoyed and bite even at a rag, and Christmas-fish, for the reason that it approaches the harbors about the time indicated.

Very nearly related to the Pleuronectids, but apparently of a different family — the SOLEIDÆ — are the sole and its many relations. They are more or less elongated, compressed, elliptical fishes, with a rounded protuberant snout, the upper eye further forward than the lower; the mouth in nearly a horizontal curve, and the opercular bones invested and concealed by the thick skin. The species are numerous, and most are of small size; in the intertropical seas are the homes of a large proportion, but some are found in the northern as well as southern temperate waters, and mostly belong to different genera from the tropical forms.

The famous sole of England is a fish of a long elliptical form, with moderate-sized pectoral fins developed upon both sides, no visible nostrils upon the blind side, and of a grayish or brownish color, with the right pectoral marked by a black blotch at its distal and upper half. It reaches a goodly size, and sometimes becomes quite large. The largest of which we have record was twenty-six inches long, and weighed nine pounds; another weighed seven and a half pounds; and still another two feet long weighed six and a half pounds. The average, of course, is much less, and somewhere near a pound.

The habitat of the sole is nearly the same as the turbot, being found in and from the Mediterranean to the Scandinavian shores. According to Dr. Day, it "appears to prefer sandy or gravelly shores," but is "rather uncertain in its migrations, for, although mostly appearing at certain spots almost at a given time, and usually decreasing in numbers by degrees, in other seasons they disappear at once, as suddenly as they arrived." Along the British sea coast "they retire to the deep as frosts set in, revisiting the shallows about May, if the weather is warm, their migrations being influenced by temperature." The food of the sole is, to a considerable extent, molluscous, but it is also said to eat the eggs and fry of other fishes and sea-urchins.

The spawning season is "late in the year and during the spring months." The ova are in moderate number; a sole of one pound weight has, according to Buckland, about 134,000 eggs. The newly-hatched, according to Dr. Day, do not appear to be commonly found so far out at sea as some other species. They enter into shallow water at the edge of the tide, and are very numerous in favorable localities.

As is well known, the sole is one of the most esteemed of European fishes. In the words of Dr. Day, "the flesh of this fish is white, firm, and of excellent flavor, those from the deepest waters being generally preferred." "Those on the west coast and to the south are larger as a rule than those towards the north" of the British islands. In addition to its use as food, it is available for another purpose. The skin is used for "fining coffee, being a good substitute for isinglass," and also as "a material for artificial baits."

The markets are generally supplied by the trawl. "The principal English trawling ground lies from Dover to Devonshire. They may be taken by spillers, but are not commonly captured with hooks; it is suggested that one reason may be that spillers are mostly used by day, whereas the sole is a night feeder." They are sometimes angled for with the hook, baited with crabs, worms, or molluscs; the most favorable time for fishing is at night, "after a blow, when the water is thick, while a land breeze answers better than a sea breeze."

The nearest American relative of the sole is a shorter fish destitute of pectorals, for which reason it has been named *Achirus lineatus.* It is a worthless animal, as one of its popular names — hog-choker — suggests. The name sole is misapplied on the Pacific coast to several true Pleuronectids.

Order VIII. — HEMIBRANCHII.

The well-known sticklebacks are the most familiar representatives of another order of true fishes. Although the external appearance may not excite suspicion of essential distinction from the ordinary Acanthopterygians, an examination of the skeleton reveals differences that have been regarded as of ordinal value. The shoulder-girdle does not have two bones, as usual, connecting the larger one with the cranium, but a single one connects the proscapula, or largest bone of the shoulder-girdle, with the skull. In addition to this, the pharyngeal bones and branchial arches generally are reduced, and some elements deficient. It is to this imperfection of the branchial apparatus that the ordinal name — Hemibranchii — alludes. Six families are recognizable for the living representatives of the order.

The Gasterosteidæ are hemibranchs with the body more or less fusiform and elongate; the sides naked, or covered with a more or less extended row of vertical shields, and the head acute or produced into an almost tubiform snout; the back is armed with stout, pointed spines; the ventrals are sub-thoracic, and each has a spine and one or two rays. Stickleback is a general name, alluding to the strong dorsal spines, for all the forms of the family Gasterosteidæ, but numerous other names are given.

The species are confined to the northern hemisphere, and are all of small size, and some are very minute, and among the smallest of fishes. In Europe three genera occur, one almost confined to the sea and the others indifferently inhabiting salt and fresh water. In the United States four genera are developed, two brackish water ones in common with Europe, and two peculiar to the United States and quite distinct from

the others. All are singular among fishes in their mode of building a nest, and the provision which nature has made for such a task. It is the male alone that is the nest-builder, and he is provided with a special organ or gland. According to Mr. John A. Ryder, this secreting gland is "a large vesicle filled with a clear secretion, which coagulates into threads upon contact with water. It appears to open directly in front of the vent." "As soon as it is ruptured it loses its transparency, and what ever secretion escapes becomes whitish after being in contact with water for a short

FIG. 156. — *Gasterosteus aculeatus* and *Spinachia spinachia*, sticklebacks.

time. This has the same tough, elastic qualities as when spun by the animal itself, and is also composed of numerous fibres, as when a portion is taken which has been recently spun upon the nest." Thus provided, when the nuptial season has arrived, the male stickleback prepares to build his nest wherein his mates may deposit their eggs. How this nest is built, and the subsequent proceedings of the stickleback, have been told us in a graphic manner by Mr. John K. Lord, from observations on a western American species, although the source of his secretion was misunderstood.

"The site is generally amongst the stems of aquatic plants, where the water always flows, but not too swiftly. He first begins by carrying small bits of green material, which he nips off the stalks, and tugs from out the bottom and sides of the banks; these he attaches by some glutinous material, that he clearly has the power of secreting, to the different stems destined as pillars for his building. During this operation he swims against the work already done, splashes about, and seems to test its durability and strength; rubs himself against the tiny kind of platform, scrapes the slimy mucus from his sides to mix with and act as mortar for his vegetable bricks. Then he thrusts his nose into the sand at the bottom, and, bringing a mouthful, scatters it over the foundation; this is repeated until enough has been thrown on to weight the slender fabric down, and give it substance and stability. Then more twists, turns, and splashings to test the firm adherence of all the materials that are intended to constitute the foundation of the house that has yet to be erected on it. The nest, or nursery, when completed, is a hollow, somewhat rounded, barrel-shaped structure, worked together much in the same way as the platform fastened to the water-plants; the whole firmly glued together by the viscous secretion scraped from off the body. The inside is made as smooth as possible by a kind of plastering system; the little architect continually goes in, then, turning round and round, works the mucus from his body on to the inner sides of the nest, where it hardens like tough varnish. There are two apertures, smooth and symmetrical as the hole leading into a wren's nest, and not unlike it.

"All this laborious work is done entirely by the male fish, and when completed he goes a-wooing. Watch him as he swims towards a group of the fair sex, enjoying themselves amidst the water-plants, arrayed in his best and brightest livery, all smiles and amiability; steadily, and in the most approved style of stickleback love-making, this young and wealthy bachelor approaches the object of his affections, most likely tells her all about his house and its comforts, hints delicately at his readiness and ability to defend her children against every enemy, vows unfailing fidelity, and, in lover-fashion, promises as much in a few minutes as would take a lifetime to fulfil. Of course she listens to his suit; personal beauty, indomitable courage, backed by the substantial recommendations of a house ready-built and fitted for immediate occupation, are gifts not to be lightly regarded.

"Throwing herself on her side, the captive lady shows her appreciation, and by sundry queer contortions declares herself his true and devoted spouse. Then the twain return to the nest, into which the female at once betakes herself, and therein deposits her eggs, emerging, when the operation is completed, by the opposite hole. During the time she is in the nest (about six minutes) the male swims round and round, butts and rubs his nose against it, and altogether appears to be in a state of defiant excitement. On the female leaving, he immediately enters, deposits the milt on the eggs, taking his departure through the back door. So far, his conduct is strictly pure; but I am afraid morality in stickleback society is of rather a lax order. No sooner has this lady, his first love, taken her departure, than he at once seeks another, introduces her as he did the first, and so on, wife after wife, until the nest is filled with eggs, layer upon layer, milt being carefully deposited betwixt each stratum of ova. As it is necessary there should be two holes, by which ingress and egress can be readily accomplished, so it is equally essential in another point of view. To fertilize fish-eggs, running water is the first necessity; and, as the holes are invariably placed in the direction of the current, a steady stream of water is thus directed over them."

The principal species of sticklebacks belong to three genera; there are the two-spined sticklebacks (*Gasterosteus*), the largest American members of the family, having, as the name indicates, two divergent spines on the back; the many-spined sticklebacks (*Pygosteus*), distinguished by the development of about six to ten divergent spines on the back; and the little *Apeltes quadracus*, which has three free spines on the back, but is more especially distinguished by the pelvic bones being widely separated and extending along the sides, instead of being like a spear-head, and pointed at the middle of the belly, as in the other species.

The largest of all the sticklebacks, and an exclusively salt-water fish, is the *Spinachia spinachia* or *vulgaris*, the many-spined stickleback. It is readily distinguishable by its slender form, tubiform snout, much elongated tail, and numerous dorsal spines. It is confined to the eastern side of the north Atlantic.

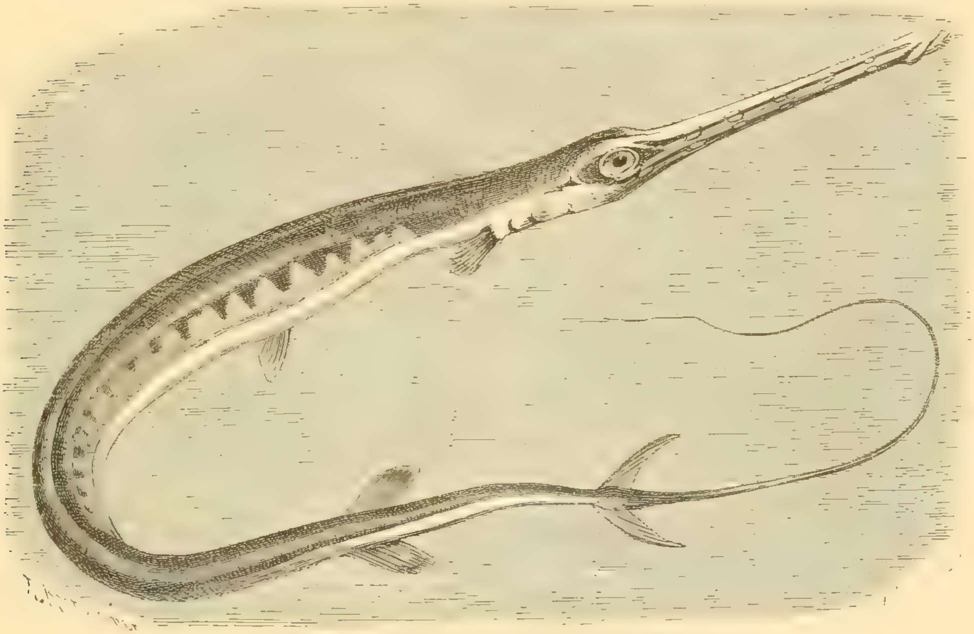


FIG. 157. — *Fistularia tabaccaria*, tobacco-pipe fish.

A family nearly related to the Gasterosteids is that of the AULORHYNCHIDÆ, distinguished by the snout being elongated and tube-like, the development of four rays besides the spine to each ventral, and of four branchiostegal rays. Two species, representing two genera, are the only known species; both are inhabitants of the north Pacific, and resemble considerably the *Spinachia* of Europe, but have a still more tubiform snout.

The name FISTULARIIDÆ is given as a family designation for Hemibranchs with the first four vertebræ very much elongated, a very long and somewhat depressed body, a long tubiform snout, and ventrals arising near the middle of the length, and having five or six rays each, but no spines; they are also destitute of dorsal spines. The two median rays of the caudal fin are united together and form a long filament extending backwards. The species are chiefly known under the name tobacco-pipe fishes; a couple of them occasionally visit the coasts of the United States, but they

are chiefly denizens of tropical seas. Little is known of their habits. The *Fistularia tabaccaria* is perhaps the most common species.

Several species of more compressed scaly fishes, with many weak dorsal spines, constitute another family — AULOSTOMIDÆ — closely related to the preceding.

A species of Hemibranch, known on the English coast as snipe-fish, is the type of another family, called CENTRISCIDÆ, or MACRORHAMPHOSIDÆ. Its representatives have a comparatively short sub-ovate body, covered with bony plates in front, and especially about the back, an elongated tubiform mouth, ventrals about the middle of the abdomen, with a spine and seven rays each, and a small distinct spinous dorsal

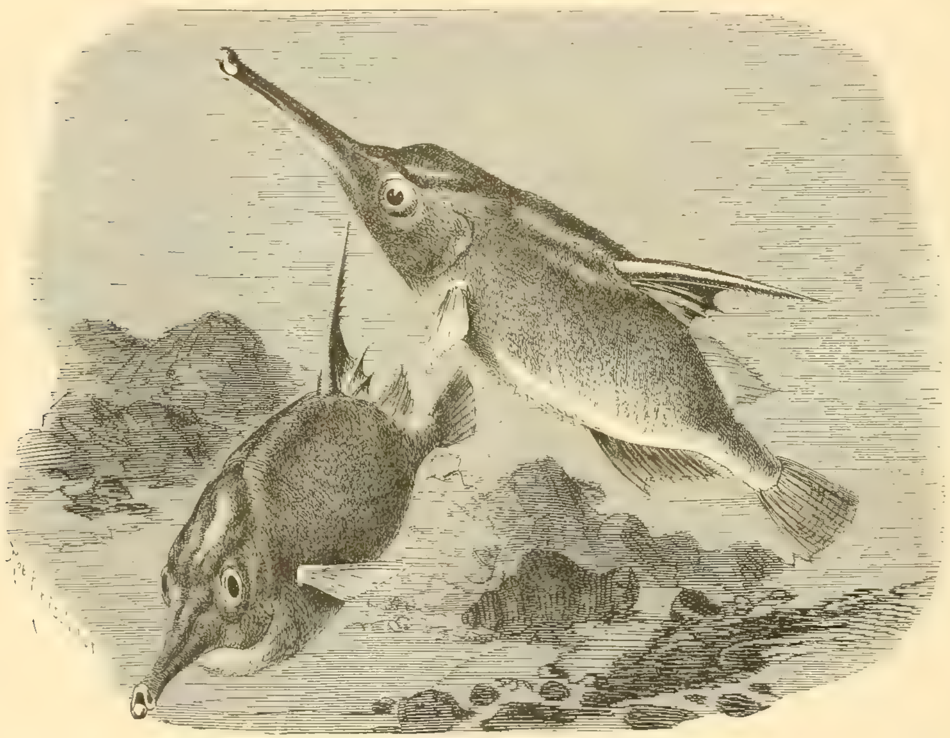


FIG. 158.—*Macrorhamphosus scolopax*, snipe-fish.

about the middle of the body. The type, *Macrorhamphosus scolopax* better known as *Centriscus scolopax*, is quite a common fish in the European seas, and one specimen of it has been found on the Massachusetts coast. It is called by the English snipe-fish and woodcock-fish.

The only remaining fishes of the order of Hemibranchs are of a very curious type known as the family AMPHISILIDÆ. These have the body excessively compressed and diaphanous, and the caudal portion is much abbreviated and deflected downwards by the encroachment of the dorsal cuirass over the dorsal fin; still further, this cuirass is composed of plates connate with the ribs, the lateral ones being developed in connection with the ribs; the head is produced into an elongate tubiform snout; the ventrals are abdominal, and there are two dorsals crowded upon the downward-bent tail. The species are confined to the Indian and Pacific oceans.

ORDER IX.—LOPHOBRANCHII.

Another order of bony fishes is represented by those known as pipe-fishes and sea-horses. The most prominent of the characters of the group is the development of the gills in the form of tufts instead of laminæ, as is usually the case; there are, however, other characteristics of still more value to be found in the skeleton, which substantiates, apparently, the title of the group to ordinal rank. Three families are recognized, two of which are well represented in the American waters.

SUB-ORDER I.—SOLENOSTOMI.

One of the families, SOLENOSTOMIDÆ, at the same time represents a sub-order, the Solenostomi. The species are very odd-looking fishes, with a spinous dorsal in front, and large ventral fins opposite it, and with the soft dorsal and anal on elevated ridges, and the body in consequence appears to be contracted between the two dorsals; the tail is very short, but the tail-fin very long. Three species have been described from the oriental seas, one of which bears the appropriate name *Solenostoma paradoxa*. The females take care of the eggs in pouches improvised by the ventral fins.

SUB-ORDER II.—SYNGNATHI.

The other two families, comprising most of the species, constitute the sub-order, Syngnathi, in which the first dorsal and ventral fins are lost.

FIG. 159.—Brood pouch of *Siphostoma*.

The family of the true pipe-fishes, SYNGNATHIDÆ, is recognizable by the very elongated body, which lies in the same axis from snout to tail. They are interesting on account of the peculiar provision for the care of their young. All of the American species have a pouch under the tail, commencing just behind the anus, which is formed by two folds of the skin meeting at the middle below. Such pouches are peculiar to the male. The female lays her eggs, and the male takes them and transfers them to his pouch, and there they are retained until the young are hatched, and their safety is thus obtained, not only in the egg state, but also a short time after they are hatched, while gaining strength for their future struggles in life. The species are numerous, and distributed in all seas, but in the North American only one genus is represented, *Siphostoma*, or, as it is more generally called, *Syngnathus*.

The most common species of the eastern coast is the *Siphostoma peckii*. The species chiefly lives among the eel-grass of the coast, and feeds probably upon the minute crustaceans that abound in such places.

The sea-horse is the type of a family (HIPPOCAMPIDÆ) of stouter fishes than the *Syngnathidæ*, and the body and the entire form more or less incline to a sigmoid curvature, the axis of the head being at an angle with the body. The characteristics of the family reach their maximum in the common sea-horses, or species of *Hippocampus*, and the likeness to a horse's head, or still more to the knights of a chess-board, is striking. The head, however, only answers to the head of a horse, and the so-called neck would constitute the greater part of the body of the sea-horse. The little fishes are chiefly to be found in eel-grass or in other vege-

tation, and are wont to twist the very prehensile tail around some stalk, and there remain, with 'neck' curved upwards, slowly wafting the pectoral fins, and imparting an undulatory or vibratory movement to the dorsal fin. Once in a while a very faint clicking sound may be heard emanating from the fish; it is like the sound produced by the pincers of an *Alpheus* shrimp rapidly moved on each other. The eggs are taken care of by the male in a sac open forwards under the tail.

The *Hippocampus heptagonus*, or *antiquorum*, is a common European species; and the *Hippocampus hudsonius* is a nearly related American form.

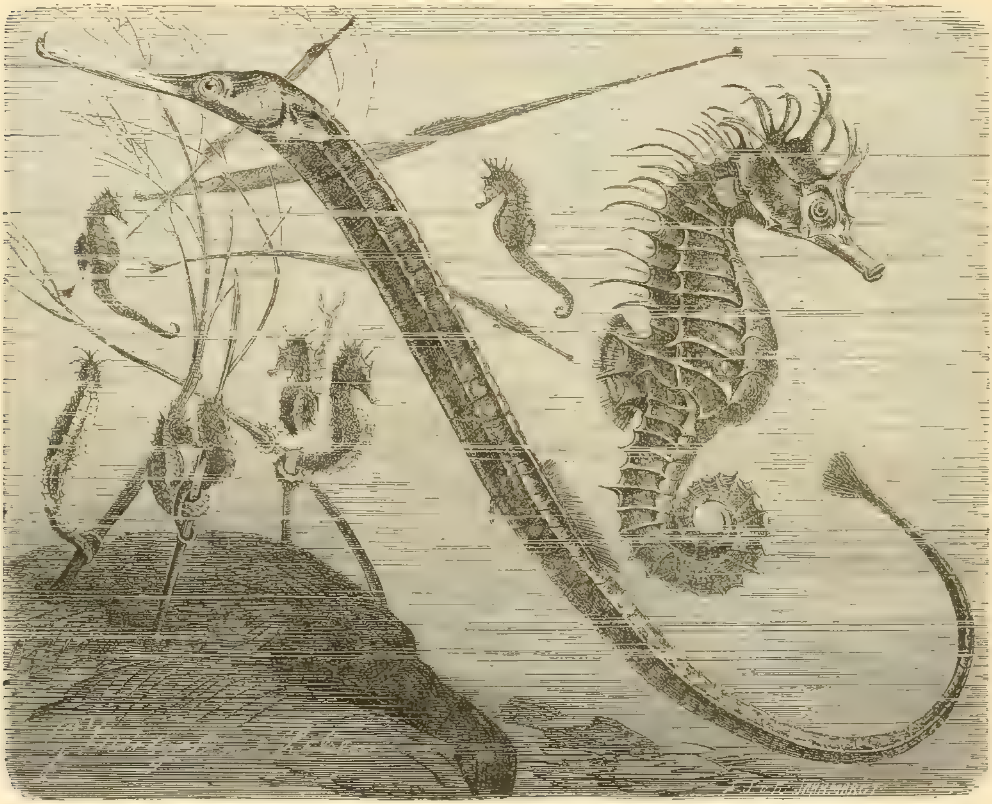


FIG. 160. — *Hippocampus heptagonus*, sea-horse, and *Siphostoma acus*, pipe-fish.

A remarkable form of this family is the genus *Phyllopteryx*, of which a couple of species are known from the Australian seas. Both bear cutaneous appendages, and in one of the species (*P. eques*), they are very long and foliaceous, well simulating the vegetation in which it lurks, concealed alike from its enemies and its prey. The eggs are carried by the male, not in a sac, as by the *Hippocampi*, but imbedded in the soft membrane under the tail portion.

ORDER X. — PLECTOGNATHI.

The next order we have to consider is one exhibiting great variation in external features, and, as a rule, they are quite unlike the typical fishes; and it is for this reason, rather than because there are any very salient structural features, that the

group has been distinguished as an order — Plectognathi. The real anatomical characters, however, are very slight, and in many, or rather most, respects, they substantially agree with those of the Teleocephali; but the elements of the lower jaw are coalesced into single pieces answering to the two rami; the supramaxillary and intermaxillary bones are also generally united (and it is in allusion to this that the name Plectognathi has been given), and the scapular arch is connected by suture with the cranium.

Sub-Order I. — Sclerodermi.

The Sclerodermis are the most generalized of the Plectognaths, and those least aberrant in external appearance as well as anatomical characters. They are, in brief,

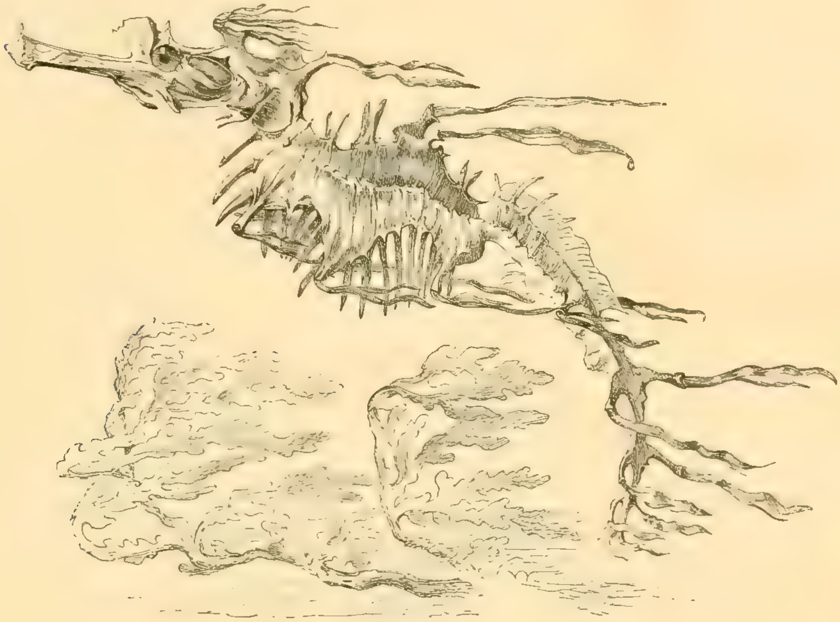


Fig. 161. — *Phyllopteryx eques.*

Plectognaths with a spinous dorsal (often reduced to a single spine) just behind or over the cranium; of a normal, fish-like form, covered with scales of regular form, or more or less spiniferous or spiniform, and with distinct teeth in the jaws.

The species which exhibit the nearest relation to any of the typical fishes are certain forms found in the East Indian and Cuban seas. These form the family Triacanthidæ. They manifest some relationship to the fishes that have been previously considered among the Teleocephali under the heading Teuthidoidea (p. 211).

The Triacanthidæ have a compressed body, covered with scales not unlike those of typical fishes, two dorsals, the first having several spines, and two large ventral spines, but no soft rays. Inasmuch as the only special interest of the family is the manifestation of the relationship of the order, we pass at once to a better-known group.

A prominent form in tropical seas is that which has been distinguished as the family Balistidæ. These are compressed fishes with scales either of a rhomboid

form and small, or reduced to spiniform appendages. The anterior dorsal fin is composed sometimes of three spines, sometimes of one; in the former case, the first spine is the largest, and, when erect, is held in place by a peculiar articulation of the second, which interlocks with it. In the others the fin is reduced to a single spine, which may be far advanced forward, even upon the head. The ventral fins are entirely wanting, but the pelvis is movable, and its extremity often manifested by a spiny armature, although in others it is entirely concealed within the integuments. The teeth are incisorial. The species are numerous and represent several sub-families.

The most common species of eastern America is one known as the trigger-fish along the southern states, leather-jacket at Pensacola as well as at Key West, and in Bermuda it is even endowed with the name of the celebrated turbot. It is said by Mr. S. Stearns to be "very common in the Gulf of Mexico, from Key West to the Mississippi River." It "lives in deep waters near the coast, on the grounds where red-snappers and groupers are caught. It is one of the most abundant species. In regions where it is not eaten, it is regarded as a pest by fishermen, from its habit of stealing bait from their hooks. Its manner of taking the bait is rather peculiar," for, instead of pulling the line downward or to one side, "it raises it upward so quietly that the fisherman does not perceive the motion, and then, by careful nibbling, cleans the hook without injury to itself. Expert fishermen, however, can tell by the 'lifting of the lead,' as it is called, what is going on below, and know what they have to contend against. The usual remedy is to seek other fishing grounds where the leather-jackets are not so troublesome. When one of these crafty fish has been hooked, there is not much probability that it can be landed; for its sharp, powerful teeth are almost sure to cut some part of the gear, enabling it to escape." Mr. Stearns had "several times known of their biting in two the large red-snapper hooks on which they were caught. They remain throughout the year on the fishing grounds, where the water varies from ten to forty fathoms. On these same grounds it is probable that they spawn."

Although rejected by many as food, it is by some, as in Bermuda, "considered a valuable food fish." But it is not only as food that it is subservient to man. Mr. Goode tells us that the skin is "used for scouring and polishing purposes at Key West and the Bahama Islands. In the Bermudas, also, the skin of the turbot is used by carpenters almost to the exclusion of sand-paper, the former being better adapted to fine work in polishing wood."

SUB-ORDER II. — OSTRACODERMI.

A single family is the type of another order, which is intermediate between the Sclerodermi and some very specialized forms to follow. The characteristics of this sub-order are the absence of a spinous dorsal, the development of the dermal covering into a solid coat of mail composed of interlocking plates, and the presence of distinct teeth in the jaws.

The only family of the sub-order, OSTRACIONTIDÆ, is distinguished by its angular polygonal form, the whole of the body except the caudal being encased in a series of large and generally hexagonal plates, whose edges mutually join, leaving no laxity whatever of the trunk. The teeth are compressed, curved, and sharp, in a single row, and generally eight above and below. Not more than a couple of dozen species are known, which appear all referable to two genera. The rigid box in which the fishes are encased entail more use of the dorsal and anal fins than is customary

among fishes, for progression. According to Mr. Goode, "the propelling force is exerted by the dorsal and anal fins, which have a half-rotary, sculling motion resembling that of a screw propeller." The caudal fin merely acts as a rudder, except in cases of emergency.

The trunk-fishes, on account of their strange form, have been long the objects of the collector's efforts, and even more so in past times than now. In the early part of the last century it appears that fishes of this kind were on exhibition at prominent taverns in Europe, and Artedi mentioned several of those in which he saw specimens. As a result of this passion, says Mr. Goode, "no group of tropical fishes is so thoroughly worked out in the writings of the fathers of natural history as this one. Over two hundred years ago, every species of trunk-fish now taken from the Atlantic was known to and described by the naturalists of northern Europe, and it is a well-deserved tribute to their discrimination as zoologists to say that none of the many efforts which have since been made to subdivide their species have been at all successful."

The trunk-fishes are, to a limited extent, used as food. It is said that in the West Indies and in Florida they are "sometimes baked in their own shells, and, when cooked in this way, are considered by many persons to be great delicacies." Their use is sometimes accompanied with danger, however; for "there are instances on record of serious cases of poisoning which have resulted from eating them. These cases occurred in tropical countries, where the flesh of fish often becomes deleterious after a few hours' keeping."

Sub-Order III. — Gymnodontes.

By far the most grotesque and unlike any true fishes are those belonging to the present sub-order. The body is enclosed in a skin which is almost sack-like, and which is capable of great distension, especially in the ventral region. The scales are reduced to very small spines (except in the Triodontidæ) imbedded in the skin, and sometimes almost or absolutely wanting. No spinous dorsal is developed, there being only a soft fin; the ventral fins are entirely wanting. The teeth are not represented as such, but are consolidated with the jaws, and these are in one piece above or below, or in two pieces in one or both jaws. Several well-marked families belong to this group.

The family of Triodontidæ is simply noteworthy for the dermal covering, which resembles that of the Balistinæ, and also for the long, movable pelvis, which likewise recalls the Balistinæ.

The chief family of the sub-order is that distinguished as Tetrodontidæ. In these the jaws are in two teeth-like pieces, both above and below; and the dorsal and anal fins are moderately developed, as is also the caudal. The skull as well as the other portions of the skeleton have a number of peculiar characters, which verify the validity of the group. In this group we have the dilatability of the abdomen often well manifested. In some species the belly is very extensible; and the names swell-fish and puffer have been given in allusion to it. The species are quite numerous, and representatives of two genera are found along the eastern American coast. They are, however, only summer residents, and have traveled or been wafted from warmer seas. On account of their remarkable form they attract the attention of most dwellers by the sea, and therefore have received numerous popular names, such as swell-fish, bottle-fish, bellows-fish, egg-fish, globe-fish, swell-toad, blower, box-fish, etc. Two species are tolerably abundant along the eastern American coast.

The most common eastern American species, *Cirrhosomus turgidus*, has the skin prickly all over, and its abdomen is very inflatable. Perhaps the most common name for it is swell-fish or egg-fish. It ranges as far north as Cape Cod, and at some points on the coast is very abundant; as at "the eastern end of Long Island, where a hundred or more are sometimes taken in one haul of a fyke-net." It frequently takes the hook. "When drawn up, it immediately inflates its body to a prodigious size by means of short, jerking inspirations, the sac becoming distended with air if in the atmosphere, or water when submerged. By scratching it on the belly, or pounding it, it will readily inflate itself several times in succession, and again discharge its load at a single effort through mouth and gills. When inflated and thrown on the water, it will sometimes float to a great distance before collapsing. The skin around the eye of this species is contractile to such an extent as to completely close up the latter by a kind of puckering." When the eye is open, however, it presents rather a pretty appearance, for the iris is of a beautiful reddish brown, and with an inner circle of a coppery or brassy color.

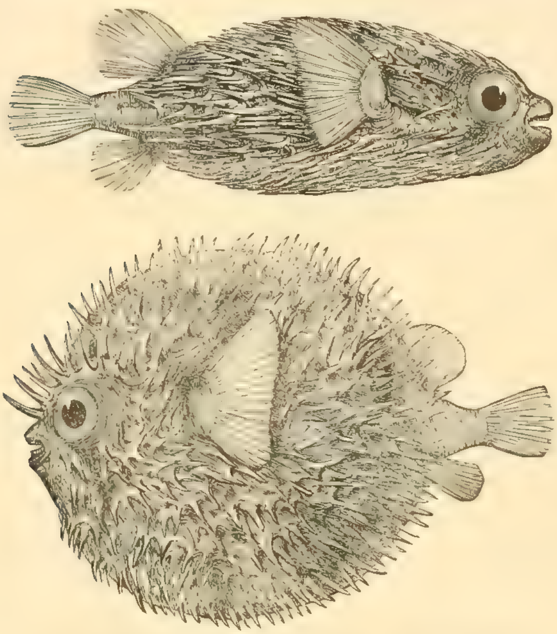


FIG. 162. — *Diodon maculatus*, globe-fish, normal and inflated.

Another species, often known as rabbit-fish (*Lagocephalus lævigatus*), is rather a straggler to the northern American coast. It is, however, a common fish in the Gulf of Mexico. It is one of the largest species of the family, and sometimes "attains the length of three feet and the weight of five or six pounds." It is used for food in some places, especially Cuba. Like its congener, it may be taken with a hook.

The *Tetrodon fahaka* is a typical and long-known species of the family, inhabiting the Nile. (See illustration on page 291.)

Two other closely related families are the PSILONOTIDÆ and CHONERHINIDÆ.

The DIODONTIDÆ form another family which is also well distinguished externally. As the name indicates, the jaws are entire, and simulate two teeth coincident with the periphery of the mouth, one above and one below. All the species of this family, too, have well-developed spines, which are generally capable of erection, and, as the fish is able also to greatly dilate its abdomen, these spines then stand outright, and give a really formidable appearance to the animal. The dilatability of the abdomen is at least as great as, and in several species greater than, in the Tetrodontidæ. The popular name porcupine-fish is the one in most general use for the various species, but several of them are also called rabbit-fishes on account of a supposed mimicry of the head of the rodent by the diodont. Three genera are represented along the American coast: *Diodon*, whose species are more especially called porcupine-fishes, *Chilomycterus*, to whose members is most applied the name rabbit-fish, and a peculiar genus

called *Trichodiodon*, remarkable for the very slender flexible spines resembling stiff hairs, and which has accordingly been named the hairy box-fish.

A typical and well-known species of the family is the *Diodon maculatus*, a Tropicopolitan fish, being found in the tropical American, and East Indian seas, as well as in the Pacific Ocean.

The last of the order is that which also is the most eccentric and aberrant. Its species seem to be only parts of fishes, the posterior end abruptly terminating and appearing as if it had been cut off and the skin grown over again; the head is mostly rounded in front, and the jaws and armature are single and without any suture above or below, thus resembling the Diodontidæ. The dorsal and anal fins are near the truncate posterior extremity, and are connected together by a posterior border or fin.

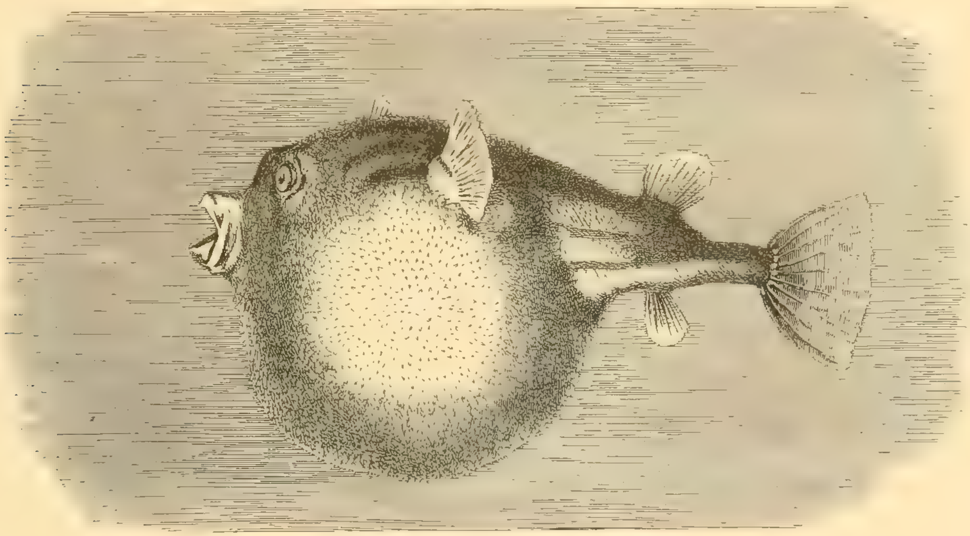


FIG. 163. — *Tetrodon fahaka*, swell-fish.

It is to this family (MOLIDÆ or ORTHAGORISCIDÆ) that the giants of the order belong, — one, the common sun-fish, sometimes weighing eight hundred pounds.

The type of the family is also the most common. Scientifically it is known as *Mola mola*, and its most common popular name, in England and America, is sun-fish. It is recognizable by its very short body, smooth skin, and erect dorsal and anal fins invested in skin, and connected by a thick skinny border around the hinder part of the body. It is a giant among fishes, and is perhaps the highest of any. Occasionally it reaches a weight of seven or eight hundred pounds, and this weight is said to be the co-ordinate of a length of seven or eight feet. Its distribution is quite extensive, for it has been found in all the temperate seas of both the northern and southern hemispheres, ranging further south in the winter. Two individuals were taken as far south even as the mouth of the St. John's River, in Florida, in the winter of 1874–75. It is a fish prone to come to the surface on sunny days, and, throwing itself on its sides, to bask in the sun. Thus floating along with one of the bright sides just on the surface, individuals may be frequently seen by the traveler along the coast. "As they float, the waves ripple and break over them, and the heavy pectoral fins move slowly to and fro through the air. Thus lying, they are very conspicuous

objects, and may be seen at long distances. They spend whole days in this position, and may be very easily approached and harpooned." It is from this habit of basking in the sun that this species takes its popular name, sun-fish.

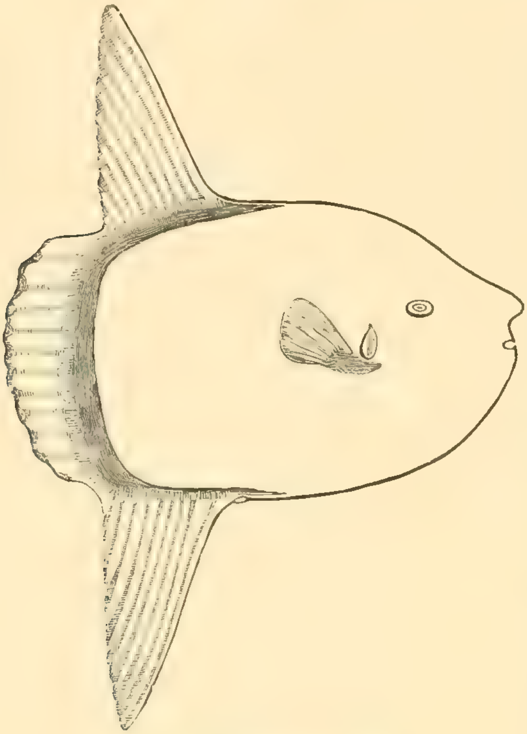


FIG. 164. — *Mola mola*, sun-fish.

The sunfish is said to feed chiefly on Acalephs, called by the sailors jelly-fish or sun-squalls. This seems to be very doubtful, however, for there is extremely little nutritious matter in the Acalephs, and the strong jaws would indicate a more substantial food.

Common as the species is, its mode of reproduction and places of breeding are still unknown. The sun-fish has been said to undergo a startling metamorphosis. There is a fish of very small size, sometimes about an inch in length, and with a very high body, with dorsal and anal fins very elevated, but without any posterior or caudal fin. This little fish, known as the *Molacanthus aculeatus*, is very rare, but occasionally it has been found even in mid-ocean, in the zones occupied by the common sun-fish. Some have even considered this little fish to be the representative of a family different from that of the sun-fish; but it has been recently contended that it is nothing but the young of the sun-fish. The evidence is not conclusive one way or another, but if the little fish is the young of the big, we have one of the most remarkable cases of development on record.

FIG. 165. — *Molacanthus pallassi.*

The uses of the sun-fish are very limited, and there is a difference of opinion in respect to its edible qualities. In Prof. Goode's opinion, as a food fish the sun-fish is probably the most worthless in our waters; the flesh is hard and thin, and, when cooked, separates into oil and bunches of tough fibres. A popular writer, however, says the flesh of the sun-fish is "white and well flavored, and is in much request among sailors, who always luxuriate in fresh meat after the monotony of salted provisions. In flavor and aspect it somewhat resembles that of the skate." Its liver, it appears, is also of some use. This is large, and "yields a very considerable amount of oil, which is prized by the sailors as an infallible remedy against sprains, bruises, and rheumatic affections."

ORDER XI. — PEDICULATI.

A group of fishes exhibiting much more trenchant characters than the Plectognathi, and equally remarkable for the eccentricity of their shapes, is that known as

the Pediculati. The chief characteristics of this group or order are the position of the gill apertures, and the reduction in number, to two or three, of the bones (actinosts) which are at the base of the pectoral fins, and which, in ordinary fishes, are four in number. The gill apertures are reduced to a simple foramen on each side, which is in the axil or behind the base of the pectoral. The actinosts are mostly very elongated, and form a pedicle or stalk to the pectoral fins, whence the name of the order — Pediculati. The scapular arch is co-ossified with the cranium, and there are other peculiar characters in the skull, which prove that the order is a distinct, as well as natural one. A remarkable feature in the development in these fishes is the extreme modification often to be seen in the first dorsal fin.

The family containing by far the most numerous species of the order is that of the ANTENNARIIDÆ. These have the first dorsal fin generally represented by three spines, the first of which is usually more or less modified into a sort of tentacle; the second is rather long; the branchial apertures are in the inferior axil of the pectorals; the mouth is wide and oblique, and the lower jaw closes in front; the pectoral fins are more or less capable of being bent downwards, and exhibit a sort of elbow at the junction with the bones at the base, or the actinosts, which are three in number. To this group belongs the little fish which is found in mid-ocean among the Sargassum weed, and which is celebrated for its nest-building proclivities. Most of the other species of the family belong to the genus known as *Antennarius*, and these live mostly in coral groves, often with head downward, where they lie in wait for prey.

Another family of the order, named CERATIIDÆ, is noteworthy as containing a number of species all of which are inhabitants of the deep sea, and some of which are very eccentric in the development of the fins and the so-called fishing apparatus. The basal bones of the pectoral fins are much less elongated than in any of the others, and their habits must be correspondingly different.

The largest and best known of the Pediculate fishes form the family LOPHIIDÆ, represented by the anglers. These have the branchial apertures in or behind the anterior axils of the pectoral fins; the anterior dorsal fin is divided into three parts; in the first there are three disconnected spines, and behind are three smaller ones united into a continuous fin; the second dorsal and anal are of moderate length; the bones at the base of the pectorals are reduced to two, and the pectorals make scarcely any elbow with the stalks or false arms; the mouth is deeply cleft, and the lower jaw projects somewhat in front of the upper.

The name 'angler' is derived from the supposition that by means of the foremost dorsal spine, which bears leaf-like tags or appendages at the end it angles for fishes itself, lying upon the ground with its head somewhat upraised. According to Mr. S. Kent, however, this is at most only partly the case. "That the fish deliberately uses this structure as a fisherman does his rod and line for the alluring and capture of other fish is a matter of tradition handed down to us from the time of Pliny and Aristotle, and which scarcely any authority since their time has ventured to gainsay. Nevertheless, like many of the delightful natural-history romances bequeathed to us by the ancient philosophers, this one of the angler-fish will have to be relegated to the limbo of disproved fiction. The plain and certain ground of facts, all the same, has frequently more startling revelations in store for us than the most fervid imaginations of philosophers, and that this assertion holds good in the case now under consideration must undoubtedly be admitted. It is here proposed to show, in fact, that the angler is one of the most interesting examples upon which nature has exercised her handicraft, in

the direction of concealing the identity of her protégé, such ingenuity being sometimes utilized with the object of protecting the organism from the attacks of other animals, or, as illustrated in the present instance, for the purpose of enabling it by stealth to obtain prey, which it lacks the agility to hunt down after the manner of ordinary carnivorous fishes. To recognize the several details here described, it will not suffice to refer to examples simply — and usually most atrociously — stuffed, nor even to those preserved in spirit, in which all the life colors are more or less completely obliterated, and the various membranous appendages shrunk up and distorted. In place of this, a healthy living example fresh from the sea, or, better still, acclimatized in the tanks of an aquarium, must be attentively examined, and whereupon it will be found that this singular fish, throughout the whole extent of its superficies, may be appropriately designated a living sham." It was, in the first place, observed by Mr. Kent, "that the fish, while quietly reclining upon the bottom of its tank, presented a most astonishing resemblance to a piece of inert rock, the rugose prominences in the neighborhood of the head lending additional strength to this likeness. This resemblance being recognized, it was next found, on a little closer inspection, that the fish constituted, in connection with its color, ornamentations, and manifold organs and appendages, the most perfect facsimile of a submerged rock, with that natural clothing of sedentary animal and vegetable growths common to boulders lying beneath the water, in what is known as the Laminarian zone. In this manner the numerous simple or lobulated membranous structures dependent from the lower jaw, and developed as a fringe along the lateral line of the body, imitate with great fidelity the little flat calcareous sponges (*Grantias*), small compound ascidians, and other low organized zoophytic growths that hang in profusion from favorably situated submarine stones. That famous structure, known as the angler's 'rod and bait,' finds its precise counterpart in the early growing phase of certain sea-plants, such as the oar-weed (*Laminaria*), while the more posterior dorsal fin rays, having short lateral branchlets, counterfeit in a like manner the plant-like hydroid zoophytes known as *Sertulariæ*. One of the most extraordinary mimetic adaptations was, however, found in connection with the eyes, structures which, however perfectly the surrounding details may be concealed, serve, as a rule, to betray the animal's presence to a close observer. In the case of the Angler, the eyes during life are raised on conical elevations, the sides of which are separated by darker longitudinal stripes into symmetrical regions, the structure, as a whole, with its truncated summit upon which the pupil opens, reproducing with the most wonderful minuteness the multivalve shell of a rock-barnacle (*Balanus*). To complete the simile, the entire exposed surface of the body of the fish is mapped out by darker punctated lines into irregular polygonal areas, whose pattern is at once recognized by the student of marine zoology, as corresponding with that of the flat, cushion-like expansions of the compound tunicate, *Botryllus violaceus*. Thus disguised at every point, the angler has merely to lie prone, as is its wont, among the stones and debris at the bottom of the sea, and to wait for the advent of its unsuspecting prey, which, approaching to browse from what it takes to be a flat rock — differing in no respect from that off which it obtained the last appetizing morsel of weed or worm — finds itself suddenly engulphed beyond recall within the merciless jaws of this marine impostor."

Half a dozen species of anglers have been described, the best known being the one common to the northern parts of Europe and America, the *Lophius piscatorius*, which is figured on page 177.

The common angler, *Lophius piscatorius*, is better known along the New England coast as goose-fish or monk-fish. It is found occasionally as far south as Chesapeake Bay, or even Cape Lookout, but is exceptional there, or at least confined to deep water, for the fishermen do not generally know it. In its northern range, however, and along the coast of New England, it is abundant, and may be found from the shoal waters to a depth of three hundred fathoms or more, as off Newport, Rhode Island. It has not been detected north of Nova Scotia. With its enormous mouth, which can only be appreciated by looking into it from the front, it may be easily distinguished from every other denizen of the American waters. Some of the numerous popular names allude to the size of the mouth and its capacity, such, for example, as 'all-mouth,' 'wide-gap,' 'kettle-maw,' and 'wide-gut.' This is also one of those fishes to which has been applied that popular name of English sailors and fishers, 'devil-fish.' The angler is a sluggish animal, generally lurking upon the bottom in the midst of sea-weed, but occasionally it may be seen swimming on the surface. It is an ex-

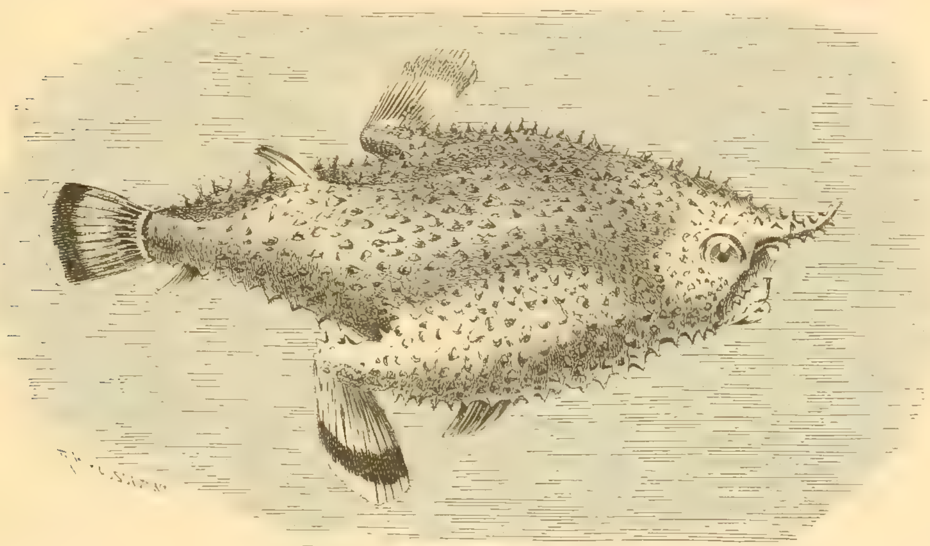


FIG. 166. — *Malthe vespertilio*, bat-fish.

tremely voracious fish, and the most common of the American names, 'goose-fish,' alludes to its capacity to master and ingest the well-known bird in its capacious maw. A fisherman told Mr. Goode that "he once saw a struggle in the water, and found that a goose-fish had swallowed the head and neck of a large loon, which had pulled it to the surface, and was trying to escape. There is authentic record of seven wild ducks having been taken from the stomach of one of them. Slyly approaching from below, they seize birds as they float upon the surface."

The angler or goose-fish spawns in summer along the eastern American coast, and the result of its labor is quite remarkable. "The eggs are very numerous, enclosed in a ribbon-shaped gelatinous mass, about a foot in width and thirty or forty feet long, which floats near the surface. One of these ribbons will weigh perhaps forty pounds, and is usually partially folded together, and visible a foot or eighteen inches from the top of the water, its color being brownish purple. The number of eggs in one of these has been estimated to be from forty to fifty thousand." The growth of the young after exclusion from the egg is rather rapid, and Prof. Goode saw " young

fish two or three inches long," while others were yet spawning, and these young fish were presumably the fry of those that had spawned the same year, only somewhat earlier. In a few days after hatching they present a striking appearance on account of the enormous development of the pectoral and ventral fins.

The last family of the order is that of the bat-fishes, or MALTHEIDÆ. Some have the forehead produced forwards into a more or less elongated kind of snout, and the first dorsal is reduced to a single short appendage which is lodged in a cavity under the snout-like prolongation, and just above the mouth; the mouth is horizontal and transverse, and varies in size in the different species; the branchial apertures are in the superior axils of the pectoral fins, instead of the inferior, as in most of the others. The best-known species is that generally called bat-fish (*Malthe vespertilio*). It is said that the fish assumes an almost toad-like attitude on the ground, the head being directed slightly upwards, and the tail stretching straight backwards and held up by the anal fin, while the pectorals assume the function of *hind legs* and the ventrals of fore ones. It is an inhabitant of the tropical and warm eastern American coast waters. Several curious specimens of the family are inhabitants of the deep sea.

The long roll-call of the fishes is finished! It had been revised, and none but the living retained, among the Teleosts at least. But our conception and knowledge of the class would be deficient were no reference made to the dead, and without some hints as to the genealogy of the chief groups.

The ancestors of the fishes — but not fishes themselves — must have existed in the earliest fossiliferous periods of which we have knowledge. But they were soft-bodied animals, destitute of internal as well as external skeleton. For unnumbered æons, animals of rank as low as, or still lower than, the lancelet, must have tenanted the ancient seas, and, quite likely, even the rivers. All there was of skeleton consisted of a long membranous substance running lengthwise in the body, and between the narrow channel serving for the passage of the nervous cord and the larger cavity containing the viscera; there was even no rudiment of a skull; there were but rudiments of a brain and heart; the branchiæ were represented by simple bars between lateral slits in the front part of the intestinal canal; all there was of fins consisted of median and low anterior lateral folds; other parts of the organization were equally inferior. Such were of the class of LEPTOCARDIANS. It must have been long afterwards when the longitudinal axial rod had become more developed, and in connection therewith a kind of skull came into being; then also a more complicated branchial skeleton had been developed; brain, heart, liver, and other viscera had become specialized, and could have been recognized as such with readiness. The forms were doubtless diversified and numerous; probably in most lateral folds continued, and in some were perhaps even differentiated into anterior and posterior fins. But all such died out without leaving any yet discovered traces, and the only known representatives are those of the class that has been named MYZONTS and MARSIPOBRANCHIATES: those which have continued to the present time became elongated and eel-like in form, and consequently lost entirely the lateral folds or fins; furthermore they become partial parasites, and doubtless to this habit the two widely distinct orders represented by the hags and lampreys owe their continued existence.

From some type of the group so represented were born forms which became more and more developed; scale-like indurations of the integuments supervened, a concrescence of the cephalic cartilages resulted in a "skull," pectoral and ventral fins

became differentiated, and scales around the margins of the jaw became teeth. With the materials for great diversity, great diversity ensued. The class of Selachians had come into existence, and long reigned the highest of Vertebrates, and still remain, represented by two divergent groups; on one hand the Holocephals, on another the Sharks, with the Notidanids nearest the ancestral types, and the Rays most distant and specialized.

From a type most resembling the Holocephals of familiar forms, another group in time originated. A concrescence of the scales took place forwards, in the form of plates on the head and behind the head, which dipped inward upon the skull and shoulder-girdle, and, still later, became in their turn covered by the skin, and membrane bones were constituted, the branchial skeleton became concentrated in the back of the head. The class of Fishes was then definable. Increased diversity became manifested; a diverticulum originated from the floor of the stomach or œsophagus, and this was utilized for the respiration of air, and various forms came out of the waters, and on the land sought for food and safety. A development of the bones which supported the pectoral and ventral fins was concomitant with the change, and enabled them to slowly progress on land, where few, if any, enemies could cope with them. The Dipnoans and bichirs are modified survivors of this group. We have in them parents at once of the Teleostomous fishes and the amphibians.

For a certain tendency was exhibited by some forms, and the diverticulum lost its inchoate lung-like function, and assumed a hydrostatic one, moving round and upwards till it reached the roof of the visceral cavity under the backbone, and established a shorter communication with the uppermost arch of the intestinal canal. The air-bladder was thus developed. The type so brought into being increased and multiplied, and, even as early as the cretaceous period, had almost become the predominant group of fishes; the brain and heart, as well as other parts, had become modified, and the great horde of Teleosts was outlined. The structure and habits of those fishes were in full accord with the conditions of sea and river; not so those of the older forms. The consequences of the new order of things became evident as time rolled on. From small beginnings the Teleost crowd continued ever swelling down the stream of time, crowding out their parent stocks, and their older relatives and progenitors gradually faded out, or were forced out of existence. Coats of mail, even, were of little account; and the heavily armed Ganoids were unable to maintain their race against their light and active rivals. Most of the new stock developed innumerable eggs, or took active care of their young, and in other respects became accommodated to the changing conditions. These hunted the eggs or young of the older stock; and such raids, in connection with various elements of unfitness, resulted in the gradual diminution and final extinction of the older fishes. A few isolated groups were at last alone left of the mighty races of the olden times. On the other hand, the Teleosts invaded all waters, — the coasts, the open seas, the deep seas, the torrid seas of the equator, the ice-covered seas of the poles, the inland streams and lakes, — and adapted themselves to all conditions. Swiftness was gained by one, power of concealment by another; one took to the most limpid streams, another accommodated itself to muddy and stagnant pools; some dove down into the greatest depths, others sought escape by flight into the air from the waters when death threatened, and still others left their native element for a time to seek safety or sustenance on land. A riotous variety supervened, intense specialization in various directions became manifest, and the means by which such specializations were effected

became obliterated by the extinction of intervening forms; *orders* have become recognizable and definable, and are expressive of our knowledge as well as of our ignorance, for trenchantly definable groups are a measure of our ignorance of intermediate terms.

Compare, for a moment, the faunas of the present and the past.

The predominant forms of our times are Acanthopterygians, Malacopterygians, Plectospondyles, Nematognaths, and Apodals, and offshoots from them. A single species (*Amia calva*) represents one old order, — the Cycloganoids; a single genus (*Lepidosteus*) remains of another once widely distributed order, — the Rhomboganoids; a couple of genera (*Polypterus* and *Calamoichthys*) are left of a still more archaic order — the Crossopterygians, and three scattered genera survive of another formerly rich old-fashioned type, — the Dipnoans. Such are the fishes. The history of the Selachians is parallel. New-fashioned types are many, old-fashioned ones few.

Fish remains have been found near the base of the upper Silurian, but the earliest fauna of which we have any approach to an adequate conception is of the Devonian epoch. No Acanthopterygians, Malacopterygians, Plectospondyles, Nematognaths, Apodals, or any of their kindred had then come into being. The predominant forms were most like the Dipnoans and Crossopterygians, but not very near them. Among the nearest to the Dipnoans were, for example, *Ctenodus* and *Dipterus*, but no existing order, properly defined, seems to have been ushered in as such so early. Several curious types, such as the Acanthodines, Placoderms, Osteostracans, and Heterostracans, were conspicuous, and soon to become extinct; other types remain yet to be discriminated among the fishes of that period; the Selachians were represented by members of extinct archaic orders, and no sharks of the common modern type, much less any rays, had become developed. No remains of Myzonts or Leptocardians have been discovered, but doubtless those classes were present under diversified forms. The whole fauna was a strange one, and contrasted, as well by what it had as by what it had not, with the existing one.

How and when such forms as were characteristic of the paleozoic period died out and others gradually took their place cannot be told here. Suffice it to say that no *undoubted* Teleost fishes have been found in older formations than the cretaceous, although it may be that even a few triassic forms may prove to be the forerunners of that great group.

Another tendency was exhibited by others of the old forms. In the Devonian age were fishes that doubtless came out on the land, and the potentiality of the quadruped limbs at least became manifest.

In a synthesis of the still existing *Polypterus* and *Neoceratodus* we have the beginning of the quadrupedal vertebrate. The undivided cartilaginous coracoid of *Polypterus* has a tubercle articulating with diverging rods, and in the one we have the rudiment of a humerus, in the other the representatives of the ulna and radius, while the indifferentiated cartilage between the diverging rods is material for the carpal bones, and in bones radiating from that cartilage are the homologues of the metacarpals. The attempts of a primitive animal of such a type to travel on land might develop the fore limb, and the hind one would follow in sympathy with the other. Then we would have the first of the quadruped vertebrates — the Amphibians.

THEODORE GILL.

CLASS VI.—DIPNOI.

Having followed out two lines of the development of the fish-like vertebrates, one leading through the sharks and skates, the other through the true bony fishes, we return again to the central stem, and take up the lung-fishes, the Dipnoi of scientific terminology, which apparently lead from the ganoids to the Batrachia and the higher vertebrates. For many years but two living genera belonging to this class were known, and these, from their curious combination of characters, were bandied about between fishes and reptiles, at one time being called fish-like reptiles, and at others reptilian fish. Then, for a comparatively long time, they remained as members of the ganoids, with which they have many undoubted affinities. Exactly where they will ultimately be placed cannot be told until their embryology is studied. Of this we as yet know absolutely nothing. During this uncertainty it seems best to place them here, next the amphibians, between which and the ganoids they are the representatives of the connecting links now long extinct.

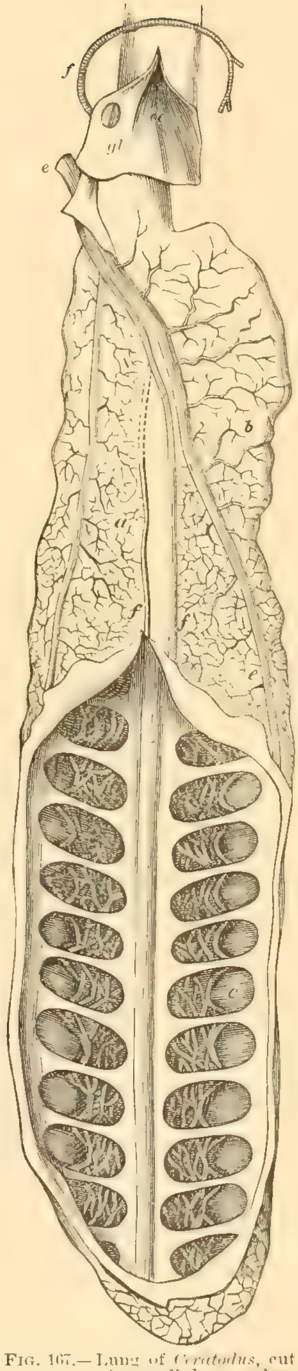


FIG. 167.—Lung of *Ceratodus*, cut open to show cellular pouches, *c*; *gl*, glottis; *e*, pulmonary vein; *f*, arterial blood vessels; *œ*, œsophagus.

In external appearance these forms are much like the ganoids. The body is long and eel-like, and, like the head, is covered by scales, and terminates in a compressed caudal fin, with weak fin-rays. The head is broad and flat, and the two pairs of nostrils are more or less within the mouth. The limbs have a jointed axial skeleton, from which, in *Ceratodus*, jointed rays diverge, but in *Lepidosiren*, only the axis remains. *Protopterus* occupies a median position in this respect. The notochord persists through life, but the neural and hæmal arches are ossified. The heart is three-parted, and is composed of one ventricle and two auricles, the second and smaller auricle receiving the blood as it returns from the lungs. This structure is different from that occurring in any of the preceding groups of fish-like vertebrates. The lungs also are well developed, as is indicated by the popular name, lung-fishes. It bears internal pouches, which considerably increase its respiratory surface, and it communicates with the œsophagus by a duct which terminates on the ventral surface of the throat, as in the higher vertebrates. In *Ceratodus* there is but one lung, but in this we observe a symmetrical arrangement into right and left halves, while in the other genera the organ is completely divided into right and left lungs. Besides the lungs, gills persist through life.

Order I.—MONOPNEUMONIA.

The simple condition of the lung sac just alluded to is one of the most marked characteristics of the family Ceratodidæ; the only member of the order. Years ago, some fossil teeth were described, from the mesozoic rocks, as the type of the genus *Ceratodus*, but, for a long time, these remained the only source of our knowledge of the genus. In 1870 Mr. Gerhard Krefft described a living species of the genus (*C. forsteri*) from the rivers of Queensland, Australia, and shortly afterward Dr. Günther of the British Museum described a second one (*C. miolepis*) from the same regions. These fishes have long been known to the natives, under the name barramunda, who highly prized their salmon-colored flesh, and ate it without regard to the scientific interest connected with the fish. The barramunda, or flat-head as the settlers call it, reaches a length of about six feet, and a weight of twenty pounds. It frequents still rivers, and feeds on the decaying leaves which fall from the trees and plants bordering

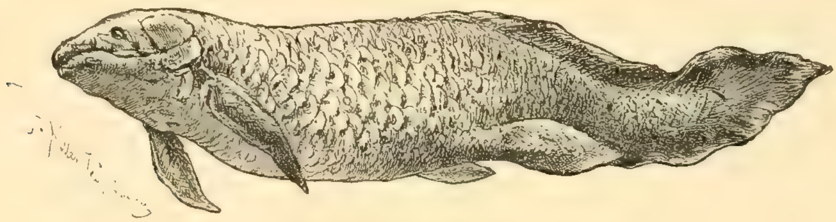


FIG. 168.— *Ceratodus forsteri*, barramunda.

the banks. It is said at times to leave the water and go on the flats, but its traveling powers cannot be great, as its weak fins seem scarcely able to support its weight, or even to drag it along. The eggs are about the size of those of a newt, and, like them, are enclosed in a gelatinous envelope. Nothing is known of the development, but this state of ignorance will not long remain, as naturalists are now on its track.

Order II.—DIPNEUMONA.

Like the last, this order contains but a single family, the Sirenidæ. The species are evidently on a higher plane than *Ceratodus*, for the lungs are better developed, and divided into two portions; the gills are more reduced; the fins smaller, and their skeleton simplified. Two genera are known, one of which, *Lepidosiren*, comes from the rivers of Brazil; the other, *Protopterus*, from tropical Africa. *Lepidosiren paradoxa* was discovered about fifty years ago, by Natterer, an Austrian explorer. He obtained only two specimens, one of which was about four feet in length. But very few have since been found, and there is hardly any animal, specimens of which are so much desired in zoological collections. It has the dorsal, caudal, and anal united into one continuous fin; the pectorals and ventrals reduced to a long and slender jointed filament; and no external gills. It is said by the natives "to produce a sound not unlike that of a cat, and to feed on the roots of the mandioca, and other vegetables." Its teeth, however, are sharp and pointed, the molars having the cusps supported by vertical ridges, facts which would indicate a diet of flesh, rather than of vegetable nature. Some recent investigations, especially those of Dr. Howard Ayres, seem to

throw doubts on the validity of this genus, and to show that both the African and the American forms are congeneric.

Protopterus annectens, the form which frequently figures in museums as the Lepidosiren is a much more common species. It is found throughout the whole of tropical Africa, but apparently is most common near the west coast. It inhabits fresh water, and feeds exclusively on fish, frogs, insects, and other animals. The body is much like that of the true Lepidosiren, but the pectoral and ventral fins have a slight fringe; and three external gill-like appendages protrude from the gill-clefts. It is covered with rather small cycloid scales, and reaches a length of about six feet. During the

FIG. 169.—*Protopterus annectens, doko, komtok.*

dry season, many of the ponds dry up, but before they are completely desiccated, the *Protopterus* descends some distance into the mud, and forms a rounded hollow for a nest. In this it lives until the rainy season releases it. The mud around one of these nests becomes very hard, and the balls thus formed have been dug out, and, without breaking, have been brought to Europe, and to this country. A short immersion in water serves to release the fish, which will live for some time in confinement. When water is plenty, the fish breathes by its gills, but when the ponds dry up, it is forced to depend upon its lungs; though, from its torpid condition, it needs but comparatively little oxygen. The natives are fond of the flesh, and in some parts of the interior it forms a considerable element in the food supply.

These three genera, *Ceratodus*, *Protopterus*, and *Lepidosiren*, have a very wide distribution, a fact which here, as elsewhere, indicates that the group is a very ancient one, and so we may expect to find remains of similar forms in the older rocks. We have already referred to the fossil teeth of *Ceratodus* from the mesozoic strata, but apparently the lung-fishes extend back to an earlier period, and some authorities claim that the Devonian fishes, *Dipterus* and *Phaneropleuron*, belong to the class of Dipnoi. These ancient forms were much more fish-like than their modern representatives, and seemed to occupy a position, in some respects, intermediate between the ganoids and the lung-fishes of to-day.

J. S. Kingsley.

Class VII. — BATRACHIA.

This class of Vertebrata is intermediate in characters, and therefore in position, between the fish-like forms and the reptiles. Among the former the Dipnoi approach it most nearly, while the extinct reptiles of the oldest order, the Theromorpha, are the nearest allies on the reptilian side. It belongs to the series of vertebrates which have

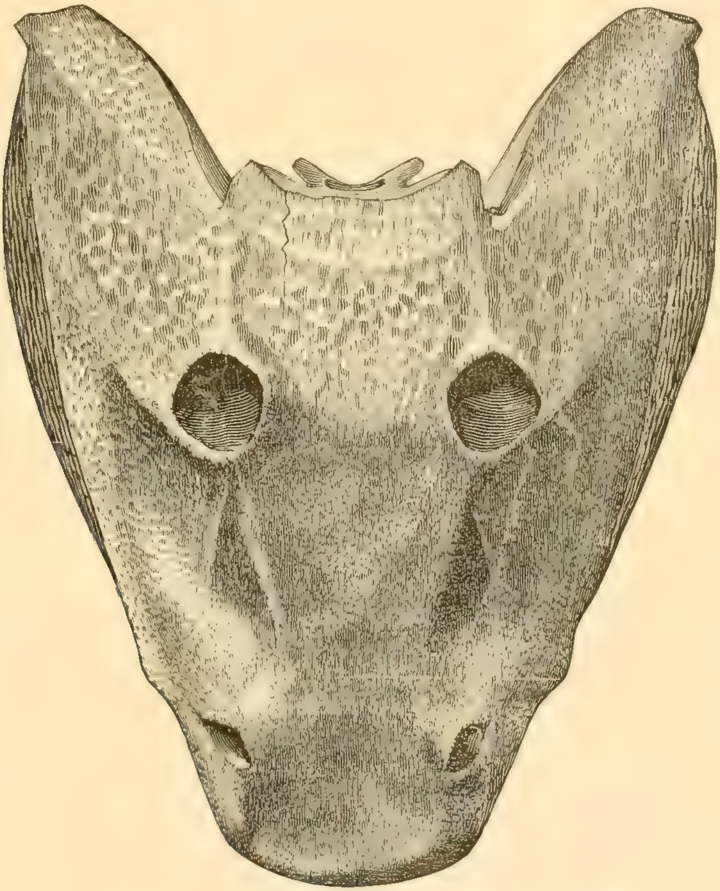


Fig. 170. — Skull of *Eryops megacephalus*, one fifth natural size.

a distinct coracoid bone in the shoulder girdle; and a distinct quadrate bone in the skull. The greater part of the basicranial axis is cartilaginous, but it is protected below by a membrane bone, called the parasphenoid. In all these respects, and in the absence of an allantois of the embryo, the Batrachia agree with the fishes. They differ from this class in the presence of legs and absence of fins, and in the absence of various bones which belong to the branchial and opercular systems, and to the suspensor of the lower jaw.

In the course of the growth of a batrachian, there is always a period which follows

the freedom of the embryo, in which there are structures for securing respiration in the water. These gills differ from those of fishes, in that the fringes in which the blood is aërated stand on fleshy processes of the branchial bones, and not directly on the bones themselves, though similar structures are found in the preliminary stages of some fishes. During this stage the tail is more or less modified as a swimming organ, and the condition of the skull differs materially in character from that of the adult. In the tailless or anurous Batrachia, the limbs do not appear until this period has nearly closed; while in the tailed or Urodele order, the limbs appear almost immediately after the gills. Besides these transitional characters, the Urodela possess in their early larval condition a long process in front of the first gill on each side, which is termed a balancer. This remains in a few abnormal cases in salamanders, but is permanent in the suborder of the Cæcilians, or worm-like Batrachia. A similar process exists in the larva of the frogs of the genus *Xenopus*, which resembles superficially a siluroid fish; but in the Anura generally, the balancers are wanting.

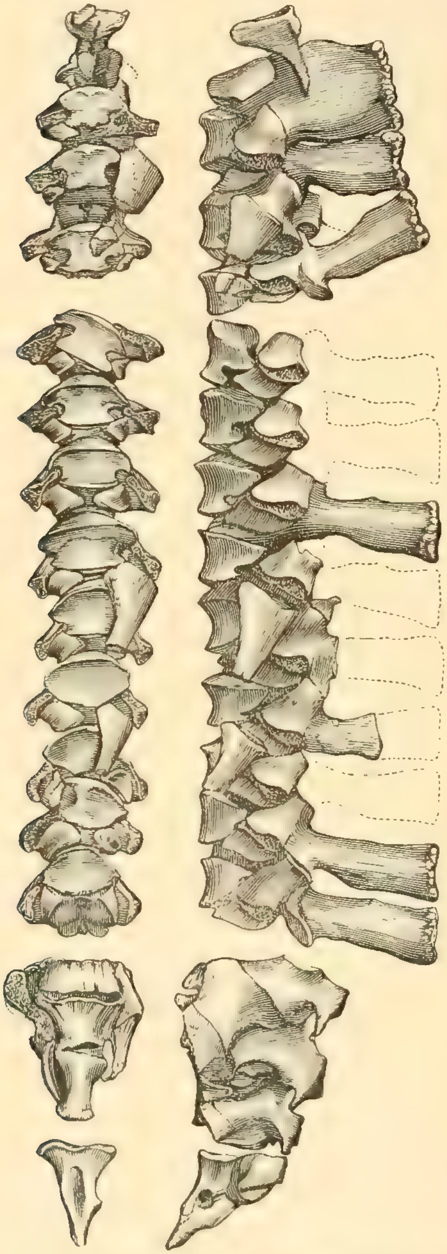


FIG. 171.—Dorsal and lateral views of vertebral column of *Eryops megacephalus*, one fourth natural size.

The gills in the Anura (frogs, toads, etc.,) are soon concealed by a growth of the skin, which leaves a small orifice for the discharge of water from the pharyngeal cavity. In one group of these animals this opening is on the middle line below, but in the great majority it is single and is situated on the left side.

The eggs of Batrachia are always deposited in the water or in damp places. In a few instances the young do not seek the water, and in one species (*Salamandra atra*) they are born alive.

ORDERS I.–V.—EXTINCT.

The class is divided into nine orders; viz., the Ganocephala, Rhachitomi, Embolomeri, Stegocephali, Proteida, Trachystomata, Urodela, Gymnophiona, and Anura. Of these the first four are extinct, and the last five have living representatives. The first two orders have the vertebral bodies represented by three segments each, a basal intercentrum, and two lateral pleurocentra (Fig. 171). In the Ganocephala, the occi-

pital condyle is obsolete, while there are two distinct ones in the Rhachitomi (Fig. 170). In the remaining orders the centrum of the vertebra is not segmented. The Embolomeri differ remarkably from all other Vertebrata, in having between the centra another set of vertebral bodies, so that each arch has two corresponding bodies. In the Stegocephali the vertebræ are simple, and the temporal fossæ are over-roofed by bone arranged in distinct segments, as in the preceding orders (Figs. 170 and 172). In the remaining orders, the temporal fossa is open above. In the Proteida there is an epiotic bone, which is unknown in the orders which follow. Like the Urodela, it has a series of distinct caudal vertebræ, and the bones of the front are not connate, and the bones of the second segment of the limbs are separate. The Urodela include the salamanders. The Gymnophiona are limbless, and without scapular and pelvic arches, and the tail is short or wanting. It includes the worm-like Cæciliidæ. The Anura, or frogs and toads, have various peculiarities of structure. The bones of the second segment of the arm and leg are co-ossified, as are the bones of the roof of the brain case. The caudal vertebræ are represented by a style or rod of bone.

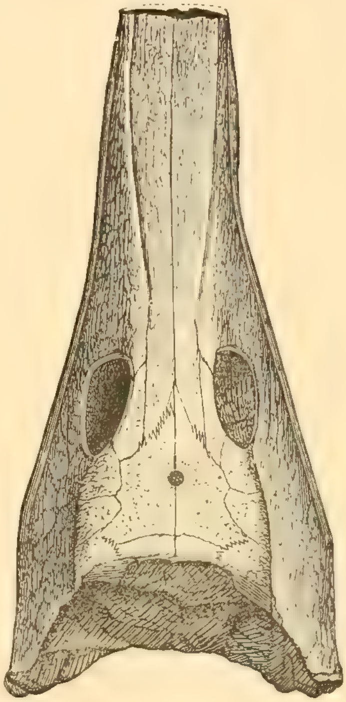


FIG. 172. — Skull of *Cricotus crassidiscus.*

The genera of Stegocephali present us with a variety of external forms, similar to those known among the Reptilia; thus *Sauropleura* resembles a long-limbed lizard, and *Tuditanus* a short-limbed one; *Amphibamus*, found in the Illinois coal-field, is a still more stout and squat form. In *Ptyonius* and *Oestocephalus* we have very elongate types, but in *Phlegethontia*, and probably *Molgophis*, we have veritable Batrachian snakes, the *Phlegethontia linearis* resembling a whip-snake in its proportions. In some of the Labyrinthodonts of the Old World we see forms rivalling the Saurians in power of armature and protective shields.

ORDER V. — PROTEIDA.

This order embraces but one recent family, the PROTEIDÆ, which includes but two genera of existing species, *Proteus* and *Necturus*. The former is represented by two or three species which live in the waters of the caves of Carinthia and Dalmatia in Austria. These animals have persistent external gills, and four legs, each of which supports but three toes in front and four behind. The powers of vision of the species are imperfect, and their colors are pale, as in other cave animals. *Proteus anguinus* is the typical species. In the genus *Necturus* there are four toes on all the feet. The larval gills are persistent in this genus also. There are two species, *N. maculatus*, of the rivers and lakes of the upper Mississippi and great lakes system, and *N. punctatus*, from the coast rivers of the Carolinas and Georgia. The color pigment is well devel-

oped in these species. The *N. maculatus* is an abundant animal in the great lakes and the Ohio and its tributaries. It is a good swimmer and is rather handsomely spotted. (Fig. 174).

ORDER VI. — TRACHYSTOMATA.

In the Trachystomata the bones of the skull are less numerous than in any of the tailed orders, since the maxillary and palatine arches are entirely absent. There is but one family, the SIRENIDÆ. These are eel-like animals with one pair of legs (the anterior) and without teeth, except a rasp-like patch on the roof of the mouth. This family contains two genera, *Siren* and *Pseudobranchus*. Both of them have the gills persistent, but in the latter genus they become functionless with age, owing to the

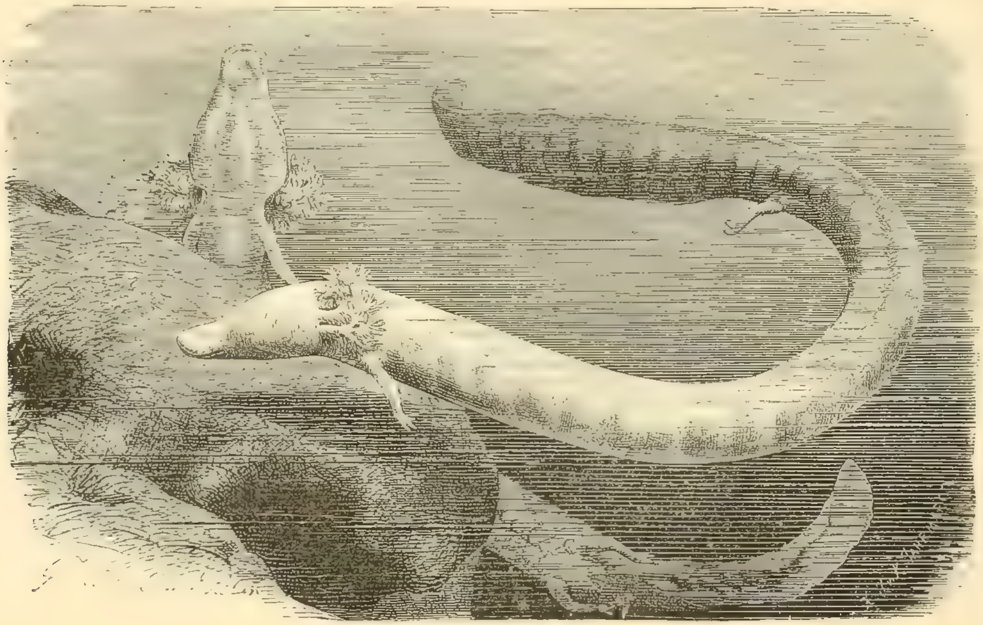


FIG. 173. — *Proteus anguinus.*

thickening of their fibrillæ. Both have four toes on the feet. The *Siren lacertina* is found in ditches in the swamps of the southern states of North America from South Carolina to the Rio Grande of Texas, and up the Mississippi as high as Alton, Illinois. It reaches a length of twenty-four inches and is of a dark lead color. The *Pseudobranchus striatus* is broadly striped with yellow, and does not exceed ten inches in length. It is not rare in Georgia and Florida.

Some years ago I had occasion to observe a *Siren* confined in an aquarium, which had been taken near Alton, Ill. (Lat. 39°). I first saw it in midwinter; it was then without gills, but frequently came to the surface and took mouthfuls of air, parts of which would escape through the slits on the neck. There were frequently convulsive movements of the latter region, by which the anterior, and sometimes the posterior slits were opened. Water was at the same time drawn in through the external

nares, and probably reached the pharyngeal cavity. The animal was said to have suffered an absorption of the gills, which lasted two weeks, during which time it would take no food; but I suspected they had been nibbled off by some sun-fish (*Pomotis*), confined in the same aquarium, who, attracted by their rosy color, thought them lawful prey. There were very small stumps remaining, of which the two anterior, seventeen days after my first observation, developed a minute brown fringe on the under side. Twenty-four days later, the stumps were longer, and the two anterior now bore a double series of processes, which were of a rosy slate color. The animal still came to the surface for air, and disliked excessively to be removed from the water. It measured nine inches and three quarters in length, and was at first pale brown, with

FIG. 174.—*Necturus maculatus*, menobranchus.

numerous black dots above, and pale slate below, but became darker, and the spots larger. There was a golden band on the side of the lip and 'cheek,' and the toes were tipped with a corneous cap.

ORDER VII.—URODELA.

This order (which embraces the salamanders) is confined to the northern hemisphere, except that two or three species extend south of the equator in the Andes. Perhaps a dozen species are found in Mexico and Central America; and of the remaining species the greater number are found in North America. The families and the distribution of their species are as follows:—

	PALEARCTIC.	INDIAN.	NEARCTIC.	NEOTROPICAL.	TOTAL.
Amphiumidæ,			2		2
Protonopsidæ,	1		2		3
Amblystomidæ,	6	1	15		22
Plethodontidæ,	1		25	9	35
Desmognathidæ,			3	1	4
Salamandridæ,	12				12
Pleurodelidæ,	13		3		16
					94

The AMPHIUMIDÆ are snake-like creatures which differ from the allied families in some characters of the skull. There are two genera, *Amphiuma* and *Murænopsis*, the former with two, the latter with three toes on the rudimental limbs. Both have a

FIG. 175. — *Siren lacertina*, mud-eel.

slit communicating with the pharyngeal cavity on each side. The *Amphiuma means* occurs in the southeastern states of North America, while the *Murænopsis tridactyla* ranges as far as the borders of Texas. These are the only species of the family. They look very much alike, with their rather acute extremities and dark color. They live in the bayous and muddy ditches of the flat coast countries.

There are but two genera of the PROTONOPSIDÆ; *Protonopsis*, of North America, and *Megalobatrachus*, of Asia. These are salamander-like animals with four well-developed but short limbs. There are branchial slits in the American genus, but none in the Asiatic form. There are but two species of *Protonopsis*, *P. horrida* and *P. fus-*

ca, the former generally distributed in the drainage of the Mississippi basin, the latter confined, so far as known, to the southern Alleghany region. *Protonopsis horrida* is the well-known hell-bender of the Ohio. It is aquatic in its habits, and is frequently caught by fishermen on their set-hooks. The following accounts of its habits are given by Messrs. Townsend and Frear in the *American Naturalist* for February and April, 1882.

"The *Protonopsis*, called 'alligator' and 'water-dog,' is an exceedingly voracious animal, feeding on fish, worms, crayfish, etc.; some of those taken by me disgorged crayfish shortly after being caught. May it not be a scavenger of the water? All my specimens were caught in the Loyalhanna creek, Westmoreland county, Pa. It is well known to those accustomed to fish in the streams of this region, from its troublesome habit of taking bait placed in the water for nobler game.

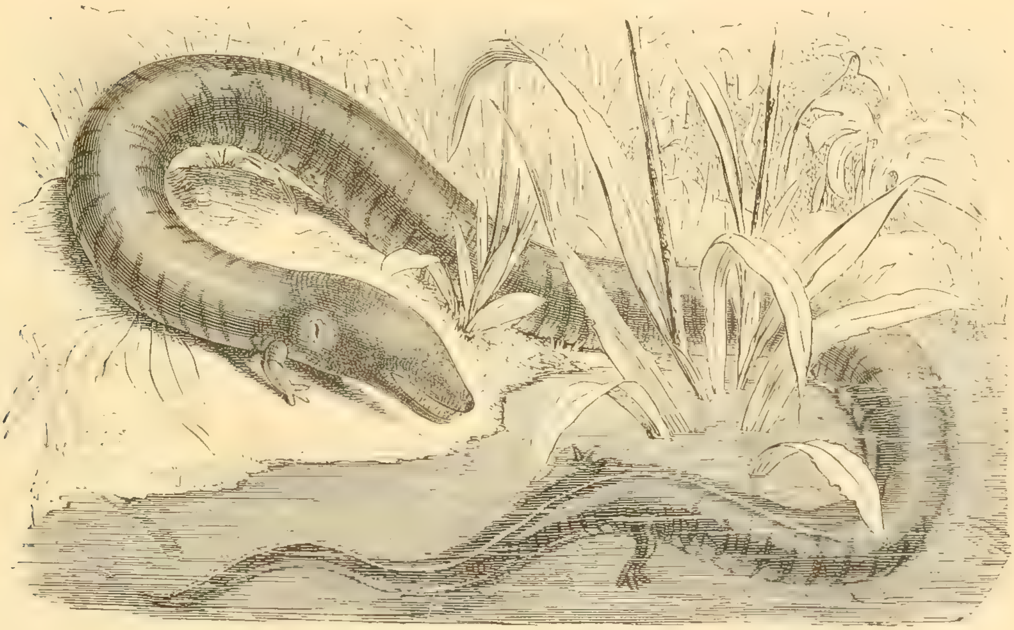


FIG. 176.—*Murænopsis tridactyla.*

When thus hooked, its vicious biting and squirming, together with the slime which its skin secretes, render it exceedingly disagreeable to handle. It is often hooked in bottom-fishing for cat-fish. Many anglers cut the hook off rather than extract it, and the amphibian's flat head is often rendered still flatter by a lively application of the sportsman's boot-heel.

"In the early summer, when the water is clear, Protonopses are often to be seen on the bottom in considerable numbers. Once, when fishing with some friends from off a large rock in the Loyalhanna creek, we saw quite a shoal of them moving sluggishly about among the stones on the bottom. They would quickly take our hooks baited with a piece of meat or a fish head. In one instance two large ones laid hold of the same bait and were promptly landed on the rock. In a few minutes we had a dozen. Last August I fished the same spot for them, but without success. Acting on the advice of a 'native' (which was to drop some bait — dead fish, etc.,

near certain rocks under which he insisted the 'alligators' stayed), I caught ten large specimens in a single morning, and ten more a few days later. Those taken were of various sizes, measuring from ten to eighteen inches in length. One taken by a friend was twenty-two inches long. Fishermen hereabouts say they have frequently caught hell-benders two feet long.

"They are remarkably tenacious of life. I carried my specimens six miles in a bag behind me on horseback, under a blazing hot sun, and kept them five weeks in a tub of water without a morsel to eat, and when I came to put them in alcohol they seemed almost as fresh as ever. During their confinement in the tub, two of the females deposited a large amount of spawn. This spawn was something similar to

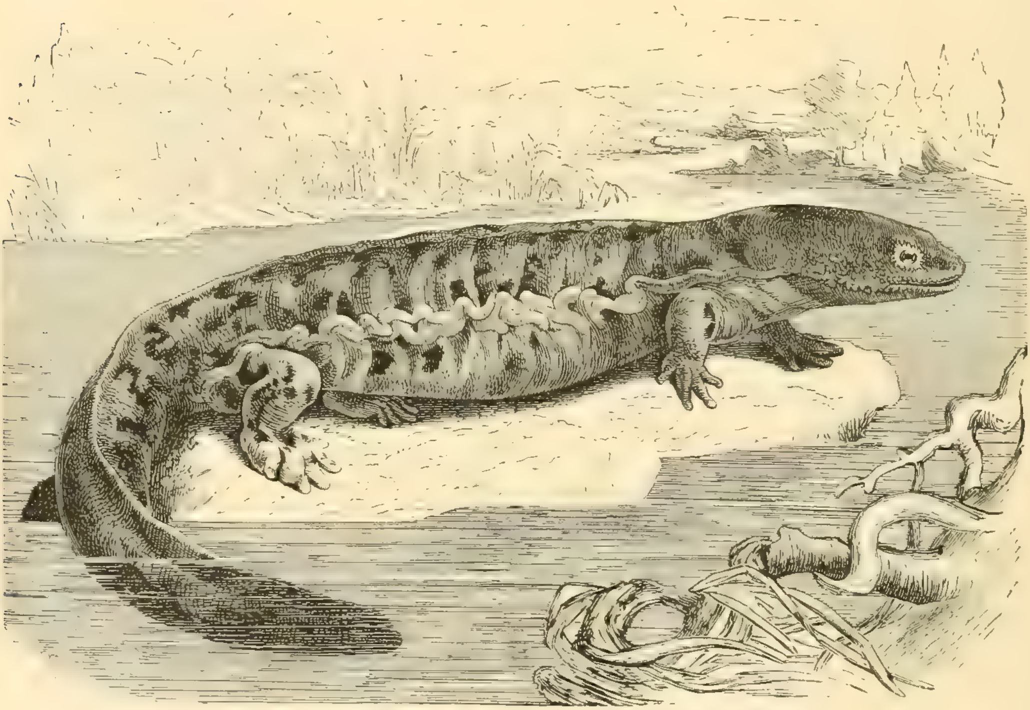
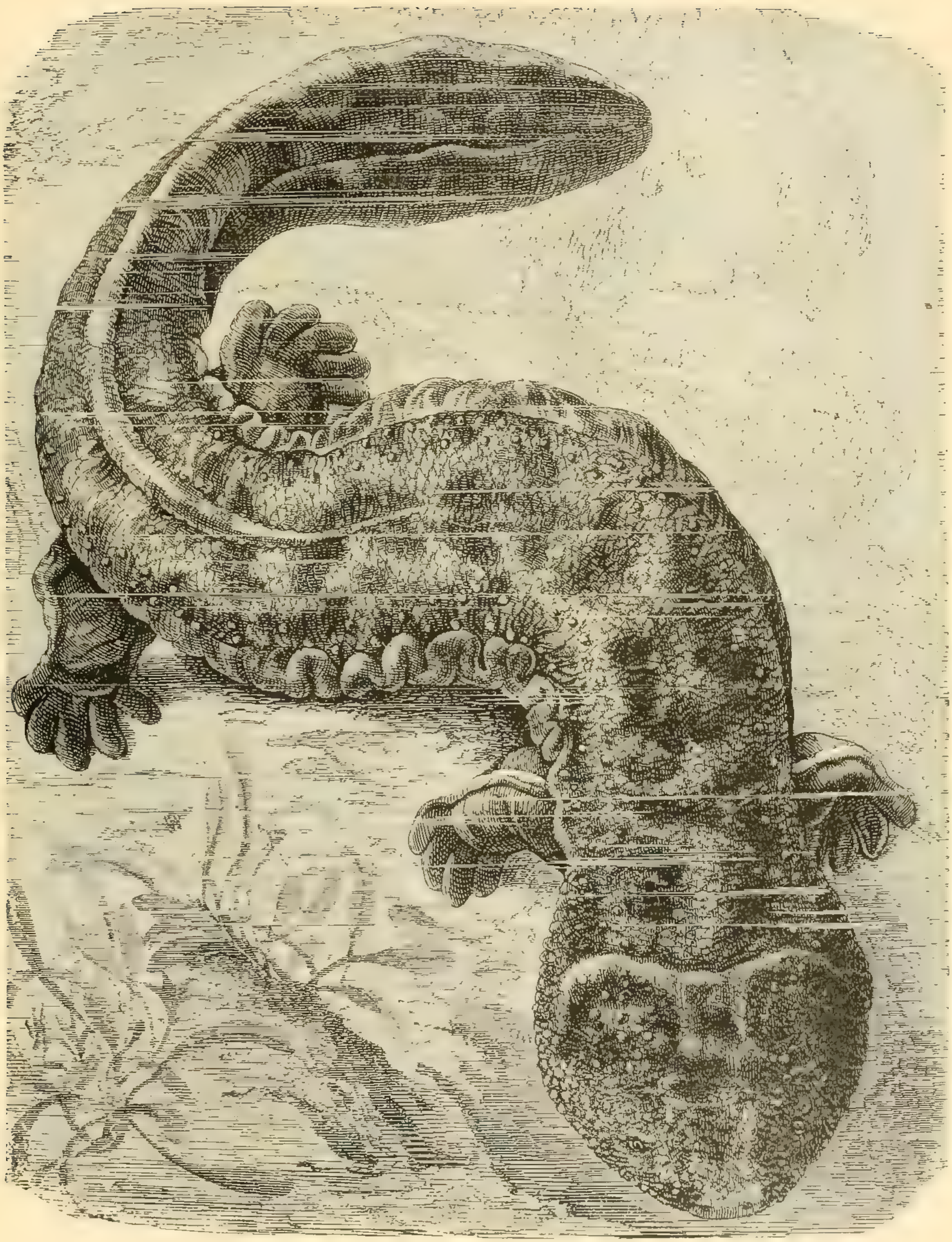


FIG. 177. — *Protonopsis horrida*, hell-bender, 'alligator,' water-dog.

frog-spawn in its general appearance, but the mass had not the dark colors of the latter. The ova were exuded in strings, and were much farther apart than frog's eggs. They were of a yellow color, while the glutinous mass which connected them had a grayish appearance. The spawn seemed to expand greatly by absorption of water. It lay in the tub among the animals for a week, but was not disturbed by them."

To the above remarks Mr. Wm. Frear of the University of Lewisburg adds: "The observations on the Protonopsis in your February number call to mind several instances of its remarkable vitality which have come under my own observation. One specimen, about eighteen inches in length, which had lain on the ground exposed to a summer sun for forty-eight hours, was brought to the museum, and was left lying a day longer before it was placed in alcohol. The day following, desiring to note a few points of structure, I removed it from the alcohol, in which it had been complete-



Megalobatrachus maximus, giant salamander.

ly submerged for at least twenty hours, and had no sooner placed it on the table before it began to open its big mouth, vigorously sway its tail to and fro, and give other undoubted signs of vitality.

"On another occasion, desiring to kill one of these creatures, which had been out of water for a day, I made a little slit in the back, hoping to be able to penetrate between the cervical vertebræ with a stout scalpel, and cut the spinal cord. After several trials, in which I succeeded only in breaking the scalpel, I gave up the attempt; but with all my cutting and pushing, it manifested not the slightest signs of pain or irritation, while if I but touched the tip of its tail with my finger, it would make a vigorous protest by lashing its tail and snapping its jaws. I doubt if even the redoubtable snapping turtle could show signs of a more 'rugged' constitution."

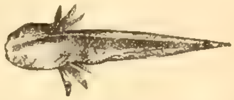


FIG. 178.—Larva of *Amblystoma punctatum.*

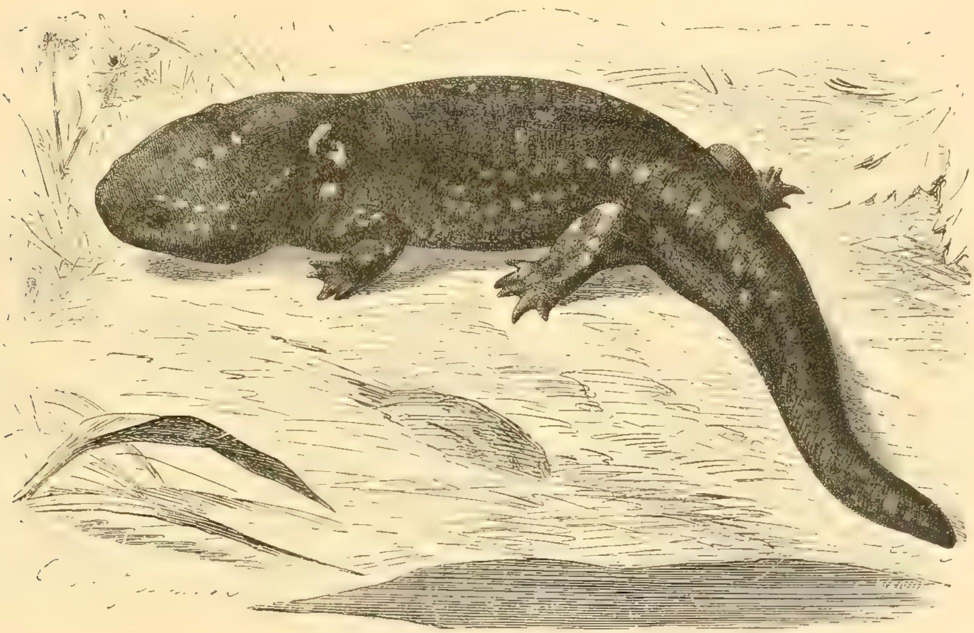


FIG. 179.—*Amblystoma tigrinum*, adult.

The *Megalobatrachus maximus*, of Japan and Thibet, is the largest living batrachian, reaching a length of three feet. It resembles its American ally in proportions and in color.

The family AMBLYSTOMIDÆ includes the genera *Amblystoma*, *Batrachyperus*, *Ranidens*, *Salamandrella*, and *Hynobius*. The first named is characteristic of North America and Mexico, where fifteen species are found, and Siam, where a single species, *A. persimilis*, has been discovered. The Amblystomata vary in size from only two inches in length (*A. conspersum*), to a foot in length (*A. tenebrosum*). The species prefer damp climates. Thus five of them are found on the Pacific coast, and ten east of the plains, while but a single species ranges over the intervening dry region of the plains and the Great basin. This one is the *A. tigrinum* (Fig. 179) which ranges over the entire continent, and southward on the Mexican plateau as far

as the City of Mexico. The species differ in the period at which they undergo their metamorphosis. Most of the eastern species reach the adult state while yet of small size, but the *A. tenebrosum* of Oregon becomes quite large before changing. The *A. tigrinum* delays its metamorphosis for the longest period, and can be prevented from completing it by continued submergence in the water. Another species, the *A. maculatum* of the Mexican lakes is not known to leave the larval state. Although it has often been affirmed that this change takes place, on examination it has always turned out that the species observed is the *A. tigrinum.* The *A. maculatum* is the axolotl of the Mexicans, and is used by them as an article of food. It is probably edible like the *Protonopsis horrida*, which I have found to be excellent.

FIG. 180.—*Amblystoma tigrinum*, larva.

The following notes on the *Amblystoma tigrinum* refer to a specimen from New Jersey of about a foot in length, which I kept for some months in a fernery in my study. It is nocturnal in its habits and remained during the day in its burrow. This extended through the long diameter of its prison, and had three outlets which it kept open. From one of them, as evening approached, it projected its head and watched with attention what was going on in the room. The *Amblystoma punctatum*, which I have also kept in confinement, has similar habits. When handled, it may eject a stream of transparent fluid, like a toad. I made the following observation on the habits of the *A. tigrinum*, at some ponds in Idaho Territory, twelve miles north of the Market Lake. On the shore I found several specimens in various stages of transition from the larval condition. They mostly presented stumps of the branchial

processes, with a greater or less degree of atrophy of the fimbriæ. These animals occupied holes the size and shape of their bodies, excavated vertically in the sand, from which their heads protruded. They were so situated as to be overflowed by every slight change of level of the water, which also kept their holes full. This situation was especially adapted to a state of transition from a branchial to a pulmonary respiration.

Next to the *A. conspersum*, the slender, gray *A. microstomum* is the smallest species of the genus. It is common in the Mississippi valley. The *A. talpoideum* is found in the forests of the South Atlantic and Gulf states. It is a robust and dark-colored species. The most brightly colored species is the *A. epixanthum* of the northern Rocky mountains, while the largest species, except the *A. tenebrosum*, is the *A. aterrimum* of the northern cascades of Washington Territory. The four remaining genera are found in Siberia and eastern Asia.

The Plethodontidæ are distinguished from the Amblystomidæ by the presence of one or two laminæ on the parasphenoid bone, which are covered by a close brush of teeth which look downwards on the roof of the mouth. There is considerable variety

Fig. 181. — *Amblystoma punctatum*, spotted salamander.

of structural character in this family. There are two principal divisions, distinguished by the form of the tongue. In the Plethodontinæ, that organ is bound to the floor of the mouth by the front border as well as the middle, while in the Spelerpinæ, it is attached by the median pedicle only, so as to resemble a mushroom in form. In these, this organ can be thrust more completely from the mouth in the capture of food, than in the other genera. In both divisions are genera with a reduced number of digits on the anterior foot; there being but four instead of five in *Batrachoseps*, and in *Manculus*. The *Plethodon cinereus* is the smallest and the most abundant salamander of the eastern United States. It is found everywhere in the woods, under bark, logs, or stones, in comparatively dry places. The variety *erythronotus* is very common, and is distinguished by the presence of a red dorsal band. Its habits are nocturnal, and it is a great climber. They will ascend the rhachis of a fern or spear of grass, scarcely strong enough to support the weight, and will lie in a coil on its apex, at a height of a foot or eighteen inches above the ground. They climb a plate of glass with ease, by adhering closely to its surface with their moist abdomen. When disturbed on some high perch among the herbage, they leap away by a sudden unbending of the coiled body, in the manner of some caterpillars.

The *Plethodon glutinosus* is most abundant in the northern states and in the Alleghany mountains. It is black with bluish white speckles. The *P. croceater* is black with large orange spots, and lives in the southern Sierra Nevadas. The *P.*

oregonensis is found in the coast range and redwood forests of California. It is of a beautiful salmon color, and has pretty prominent eyes.

The species of *Spelerpes* are often handsomely colored. The *S. longicauda* is often found in caves in the limestone regions of the southern states. It is of a slender form and a rich yellow color, with broken bands of black on the body. The *S. guttolineatus* is marked with longitudinal brown bands. It is common in the mountain regions of the south. The common northern species are *S. bilineatus* and *S. ruber*. The former is a small species, with a black line on each side of its back and a citron-yellow belly. It is especially common in stony brooks in the woods. *S. ruber* is of a brilliant red color, and is usually found in cold springs. It is more or less brown or even black spotted, and there is a variety which is of a lead color above. It remains long in the larval stage, and the larvæ are as frequently seen as the adults. *S. longicaudus*, *S. guttolineatus*, and *S. bilineatus* occasionally retain the larval balancers. These are a pair of elongate cylindric rods, one of which issues from each side of the head in the salamander larva, in front of the branchiæ. They are permanently re-

FIG. 182. — *Spelerpes longicauda.*

tained in the Cæciliæ. The largest species of *Spelerpes* is the *S. bellii* of the damp mountains of Mexico. It is lead-colored, with a double row of red spots on the back.

A genus which is confined to the neotropical region is *Œdipus.* It only differs from *Spelerpes* in having the digits united together in a common integument, which is in fact only a persistence of the condition which belongs to an early stage of the larva. The most common species, *Œ. variegatus*, is black below and yellow above. It is found everywhere with the *Spelerpes bellii*. *Œ. rufescens* is a small species which, according to Sumichrast, lays its eggs in the water that accumulates in the axils of the leaves of some of the parasitic Tillandsiæ which grow on the trees in the Mexican forests. *Œ. altamazonicus* is found in eastern Peru. Allied to this genus are some weak and slender species with the skull imperfectly ossified. They are referred to the genus *Œdipina*. *Œ. lineolus* is found in eastern Mexico, and *Œ. uniformis* is a species of Costa Rica, Central America.

In Europe one genus of Plethodontidæ is found (*Geotriton*). It has all the characters of *Œdipus*, except that the premaxillary bone is divided and not single. The only species, *G. fuscus*, is confined to northern Italy.

With the DESMOGNATHIDÆ we commence the salamanders with ball and socket vertebræ. There are but two genera known; *Desmognathus*, which is North American, and *Thorius*, which is Mexican. But three species of *Desmognathus* are known. *D. fusca* is an abundant aquatic salamander of the eastern United States. It is found in springs and damp places under stones. In common with other species of the genus it has a peculiar structure which is especially adapted for moving stones with

its nose. The temporal muscle, instead of being attached to the lateral parts of the skull, terminates in a tendon, which passes over the sides of the posterior part of the skull, and is attached to the atlas, or first vertebra. The mechanical effect of this structure is that the contraction of the temporal muscle raises not only the lower jaw, but the entire head. As though to give a freer movement to the head, the occipital condyles are produced so as to form a pair of short stems. The same kind of condyles are seen in the genus *Amphiuma*. Professor Baird originally noticed this structure, and also the curious disposition which the species makes of its eggs. As in the anurous genus *Alytes*, the eggs, on emission, are connected by an albuminous thread, which soon contracts and hardens. One of the sexes protects this rosary by wrapping it several times round the body, and remaining concealed in a comparatively dry spot until the eggs hatch.

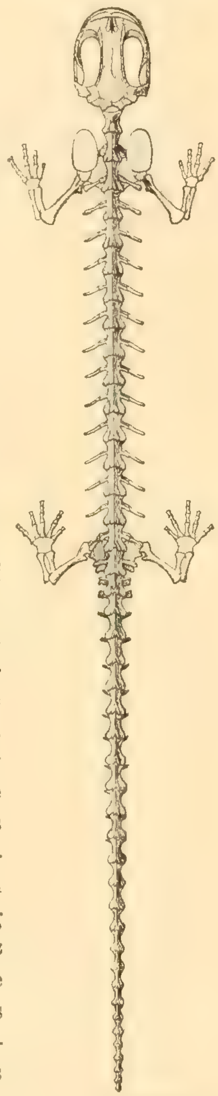


FIG. 183. — Skeleton of *Spelerpes bellii*.

D. nigra is a considerably larger species, reaching seven inches in length. Its color is entirely black. It is confined to the Alleghany mountains, where it lives in stony springs and streams. *D. haldemani* is smaller than the other species, and is brownish yellow above. It lives under bark of logs in the Alleghany mountain regions. *Thorius pennatulus* lives in similar situations in the eastern Sierra Madre of Mexico. It is peculiar for its partly membranous cranium, large nostril, and the large size of its eggs.

The family of SALAMANDRIDÆ includes four genera, and these inhabit the Old World exclusively. *Salamandra* is represented by but three species, of which the best known are the larger yellow-spotted *S. maculosa*, and the smaller black *S. atra*. The former is found in Europe generally. Its skin is very glandular and secretes much fluid, which might by its presence protect the animal from a temporary high temperature. This is probably the source of the fables respecting its power of resisting fire. *Salamandra atra* inhabits the mountains of southern Europe, and is remarkable for being viviparous, the young being born with gills. The genera *Chioglossa* and *Hemisalamandra* have no ligament passing outside the temporal muscle of the skull, while in *Molge* it is present, foreshadowing the osseous postorbito-squamosal arch of the Pleurodelidæ. *Chioglossa lusitanica*, found in the mountains of Portugal, is a dark gray species of medium size. *H. cristata* is a common species of Europe.

Of the genera of this family, *Molge* embraces the greater number of species. They are all aquatic in their habits, and are generally called tritons. *Molge palmata* is a small plain species common everywhere in Europe. *M. alpestris* has a brilliant red belly, and is found in great numbers in the ponds of melted glacier ice in some parts of Switzerland. *M. marmorata* is a large rough species which is common in France. These and others of the Palearctic fauna present remarkable developments at the breeding season. Their tails and backs acquire dermal fins along the middle line, and the toes become bordered with similar dermal margins. The muscles of the humerus become thickened in the males, appropriately to their maintain-

ing a firm grip on the females, which they seize round the groin at the time of the deposition of the eggs.

The PLEURODELIDÆ embraces a large number of species which are mostly inhabitants of the Old World. Their characteristic peculiarity is the bony postfronto-squamosal arch of the skull. In other respects they agree with the Salamandridæ; that is in having ball-and-socket-jointed vertebræ, with the socket behind, and in the posterior prolongation of the vomers, which support two longitudinal rows of teeth on the roof of the mouth. These take the place of the parasphenoid patches of the Plethodontidæ. In the Pleurodelidæ the tongue is never developed as in the Plethodontidæ, but is generally insignificant.

The larger number of species of this family are embraced in the genus *Diemyctylus*. *D. punctatus* is a common European species, which is of pale colors with brown spots, and which presents many dermal growths at the breeding season. The *D. rusconii* of southern Europe is a larger form. It has a spine-like process on the tibia, and a greatly prolonged cloaca at the breeding season. There are two or three species of *Diemyctylus* in North America. The largest of these is *D. torosus* of California,

FIG. 184. — *Œdipus variegatus*, var.

where it is very common in every small stream. It has a rough skin, and is brown above, and yellow below. It attains a length of six inches. The common triton of the stagnant ponds and ditches of the eastern states is *D. viridescens*. It is pale green above, and pale yellow below, with small black specks. It may or may not have some small round red spots, with dark borders on the sides. It generally has three shallow pits on each side of the neck, which are remnants of the old branchial fissures; these are not constant, however. This species lays one egg at a time in the axils of leaves of aquatic plants. The egg has a glutinous surface, and when the leaves are pressed over it by the hind legs of the female, they adhere to it, and conceal it, until it is hatched. A well-marked variety of this species is found in woods on the ground. It is bright red, has red spots, and is always of smaller size. It is the sub-species *miniatus*. Another strong variety or species is *D. meridionalis* from southwestern Texas. It is green, with large black blotches. There are species of *Diemyctylus* in Japan and China, which are generally marked with red.

The genus *Pleurodeles* is only found in southern Europe, chiefly in Spain. It is characterized by the long ribs which perforate the skin on each side of the body. One species, *P. waltli*, is known. In *Siranota* the postfronto-squamosal arch is so wide

as to overroof entirely the temporal fossa above. It includes but one small species, the elegant *S. perspicillata* of the mountainous regions of Italy and Dalmatia. *Glossolega* has the unique character, according to Gevais, of a complete quadrato-jugal arch of the skull. The type, *G. poireti*, which is a rather large species, with a second one, occur in Algiers. *Tylototriton verrucosus* represents the family in the eastern Himalayas.

Order VIII. — GYMNOPHIONA.

The Batrachians of this order are peculiar in various respects. The general characters of the skull do not differ essentially from those of the Urodela, but the skeleton is without scapular and pelvic arches, and limbs, and the caudal vertebræ are few or wanting. They are covered with a flexible skin, which is folded at regular intervals into rings which surround the body, and is frequently furnished with minute concealed

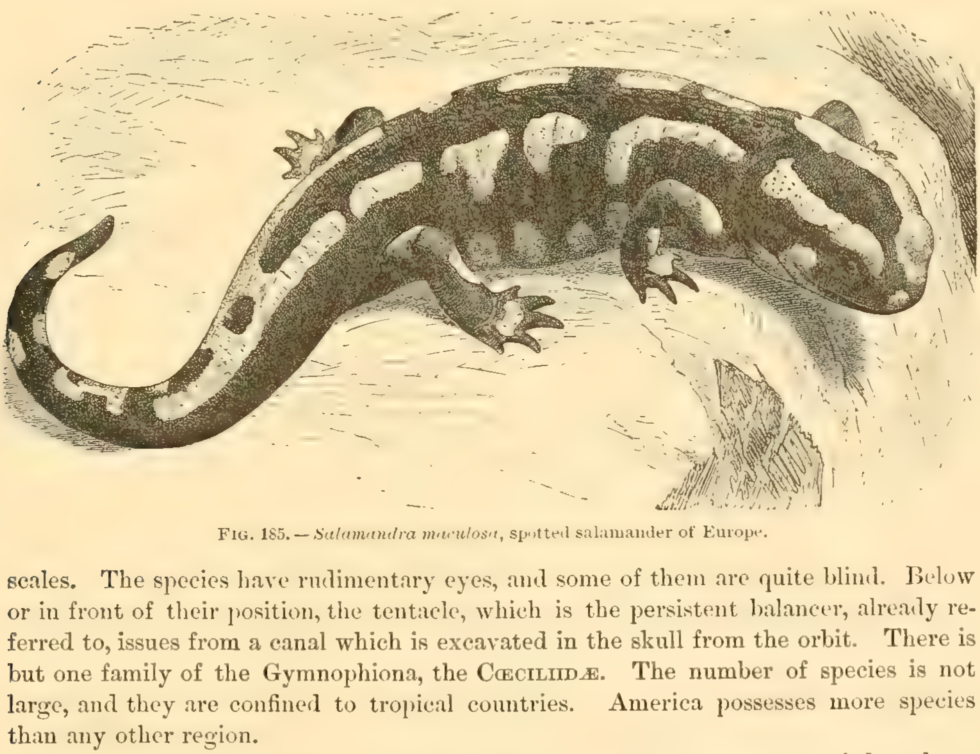


Fig. 185. — *Salamandra maculosa*, spotted salamander of Europe.

scales. The species have rudimentary eyes, and some of them are quite blind. Below or in front of their position, the tentacle, which is the persistent balancer, already referred to, issues from a canal which is excavated in the skull from the orbit. There is but one family of the Gymnophiona, the Cœciliidæ. The number of species is not large, and they are confined to tropical countries. America possesses more species than any other region.

In their early stages, the Cœciliidæ, like other batrachians, are not air-breathers. Branchial fissures connect the pharyngeal cavity with the external medium, and from their sides originate respiratory organs. These are bladder-like membranes, in which the blood vessels ramify, thus differing entirely from the gills of other Batrachia. These structures are shed, and the fissures are closed, early in life.

Order IX. — ANURA.

The order of the frogs, toads, etc., includes eight hundred species, which are referred to one hundred and thirteen genera. The entire order is divisible into four series,

which differ from each other in the structure of the shoulder-girdle and of the base of the skull. In the first of these, the eustachian canals are prolonged by an osseous roof which covers them in below, until they nearly meet on the middle line of the roof of the pharynx, so that they appear to have but one opening. This sub-order has no tongue, and is hence called the Aglossa. In the next sub-order the structure of the shoulder-girdle is similar to that of the Aglossa, while the eustachian openings are widely separated from each other, and the tongue is present. This sub-order is called the Arcifera, deriving its name from the characteristic peculiarity of the shoulder-girdle. This consists in the presence of two longitudinal cartilaginous bands with convex borders which connect the free and divergent ends of the coracoid and precoracoid

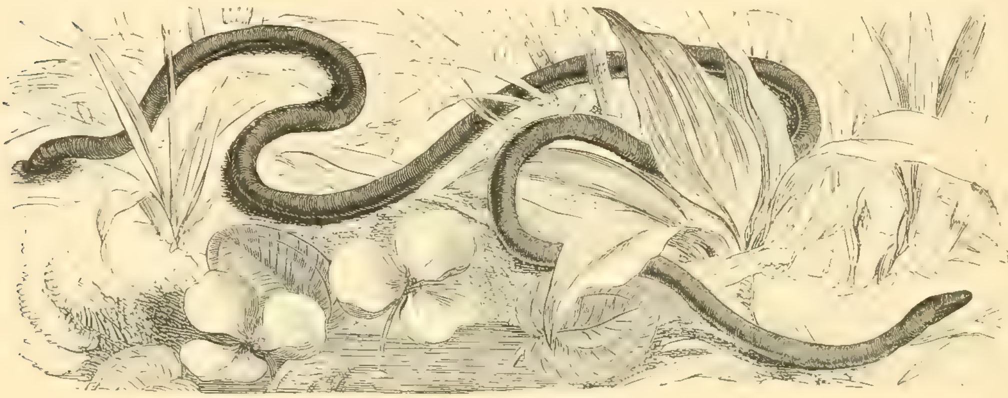


FIG. 186. — *Cæcilia lumbricoidea.*

bones (Fig. 188); the cartilage of one side overlapping that of the other. In the next sub-order, that of the Firmisternia, these cartilages are fused into a narrow median mass which intervenes between the adjacent ends of the nearly parallel precoracoid and coracoid bones (Fig 189) the whole structure being incapable of a movement which expands and contracts the thoracic cavity, as is the case in the Arcifera. In the last sub-order this region has a structure which is a modification of that of the Firmisternia, but the coracoid diverges much from the precoracoid, and the scapula is articulated to a ball joint of the proötic bone which projects on each side of the skull behind. This structure gives the scapular arch much more solidity than is found in any of the other sub-orders, affording a point d'appui for the pressure exercised by the fore legs in pushing through the earth, for the known species of this division, the Gastrechmia, are burrowers.

FIG. 187. — Larva of *Typhlonectes compressicaudus*, showing external sac-like gills.

It is an interesting fact that the frogs of the sub-order Firmisternia have, during an early stage (Fig. 190), the structure of the scapular arch which belongs to the Arcifera, the consolidation constituting a modification superadded in attaining maturity. Furthermore, young Anura are toothless, and one section of the species with embryonic shoulder girdle never acquires teeth. So here we have a group which is imperfect

in two points instead of one. This is the family of toads, or Bufonidæ. Several families have teeth and embryonic shoulder girdle. The family which has teeth and firmisternal shoulder-girdle is the Ranidæ, or true frogs. Now the frogs of each of these divisions present nearly similar scales of development of another part of the skeleton, viz.: the bones of the top of the skull. We find some in which the front one of these bones (ethmoid) is represented by cartilage only, and the middle ones, or fronto-parietals and the nasals, are represented by only a narrow strip of bone each. In the next type the ethmoid is ossified; in the next, we have the fronto-parietal completely ossified. The nasals may range from narrow strips to complete roofs. In the fourth station on the line, these bones are rough, with a hyperostosis of their surfaces; and in the next set of species, this ossification fills the skin, which is thus no longer separable from the cranial bones; in the sixth form the ossification is extended so as to roof in the temporal muscles and enclose the orbits behind; while in the rare seventh and last stage, the tympanum is also enclosed behind by bone. Now all of these types are not found in all of the families of the Anura, but the greater number of them are. Six principal families, five of which belong to the Arcifera, are named in the diagram below, and three or four others might have been added. I do not give the names of the genera which are defined as above described, referring to the explanation of the cuts for them, but indicate them by the numbers on the left margin of the page, which correspond to those of the definitions above given. A zero mark signifies the absence or non-discovery of a generic type. See pp. 320, 321.

FIG. 188.—Sternum of *Scaphiopus holbrookii*; arciferous type.

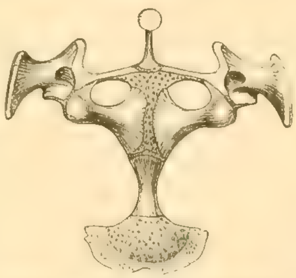


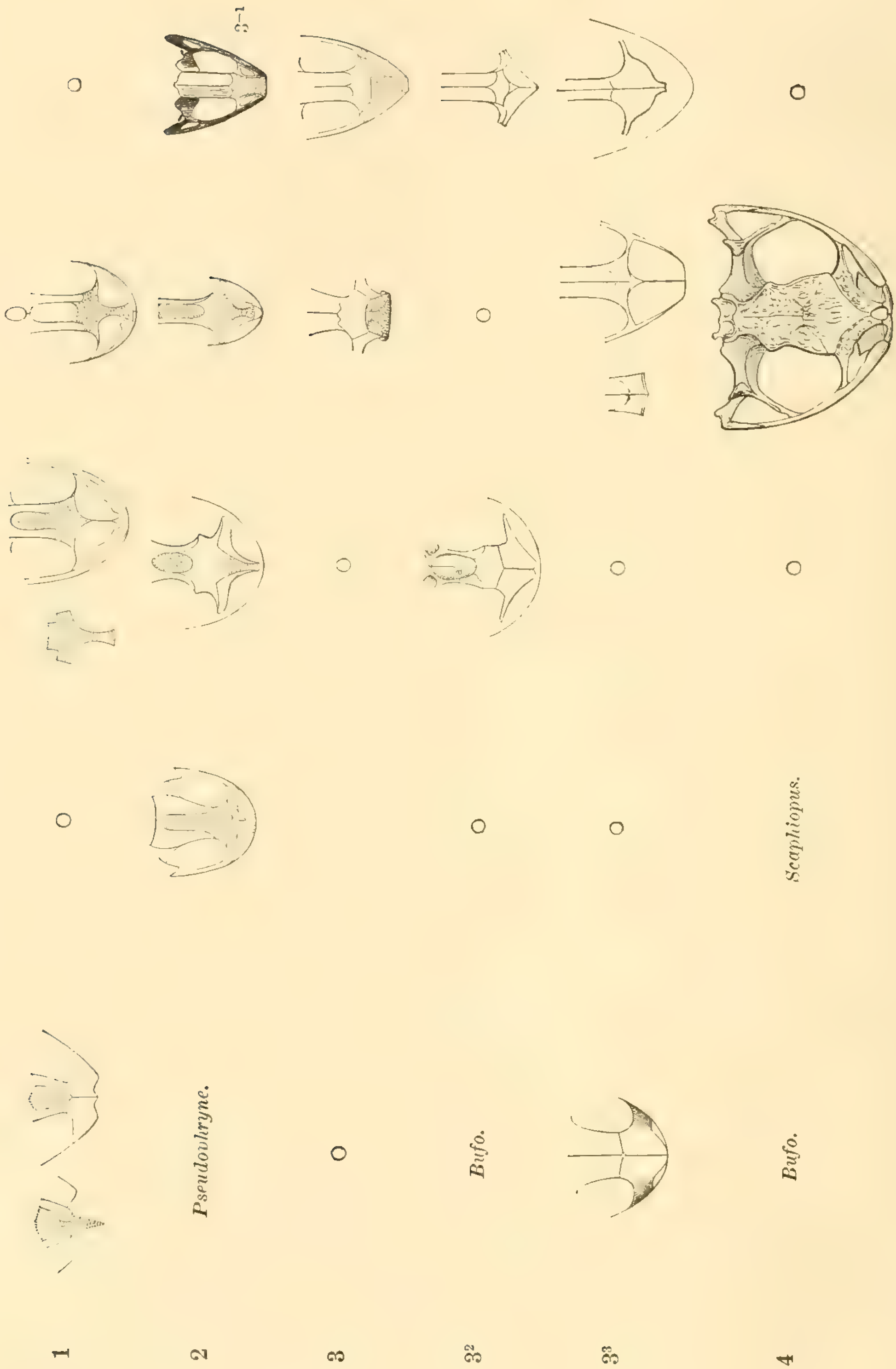
FIG. 189.—Sternum of *Rana temporaria*, firmisternous type.

	Sternum embryonic. Arcifera.				Sternum complete. Firmisternia.
	No teeth.	Teeth.			
Stages.	Bufonidæ.	Scaphiopidæ and Pelobatidæ.	Cystignathidæ.	Hylidæ.	Ranidæ.
1—	1	0	1	1	0
2—	2	2	2	2	0
3—	3	0	3	3	3
4—	4	4	4	4	4
5—	5	5	0	5	5
6—	6	6	6	6	0
7—	7	0	0	0	0

It is evident, from what has preceded, that a perfecting of the shoulder-girdle in any of the species of the Arciferous columns would place it in the series of Firmisternia. An accession of teeth in a species of the division Bufonidæ would make it one of the Scaphiopidæ; while a small amount of change in the ossification of the bones of the skull would transfer a species from one to another of the generic stations represented by the numbers of the columns from one to seven.

FIG. 190.—Sternum of a larva of *Rana temporaria*, with the limbs just budding.

There are few groups where this law of parallelism is so readily observed among


1
2
Pseudophryne.
3
3^2
Bufo.
3^3
4
Bufo.
Scaphiopus.
3^{-1}

DEGREES OF OSSIFICATION IN THE CRANIA OF ANURA.

The numbers in the side column correspond with those in the table of families in the text. The powers attached to 3, represent degrees of ossification of the nasal bone.

BUFONIDÆ. — Fig. 1, anterior part of skull of *Chelydobatrachus gouldi*, from Australia. Fig. 3^3, *Bufo carens*, South Africa. Fig. 6, *Peltaphryne peltacephala*, Cuba. Fig. 7, *Otaspis empusa*, Cuba.

SCAPHIOPIDÆ AND PELOBATIDÆ. — Fig. 2, *Didocus calcaratus*, Spain. Fig. 5, *Scaphiopus holbrooki*, United States. Fig. 6, *Cultripes provincialis*, France.

HYLIDÆ. — Fig. 1, *Thoropa misiessi*, Brazil. Fig. 2, *Hypsiboas doumerci*, Surinam. Fig. 3^2, *Scytopis venulosus*, Brazil. Fig. 6, *Trachycephalus geographicus*, Brazil.

CYSTIGNATHIDÆ. — Fig. 1, *Eusophus nebulosus*, Chili. Fig. 2, *Borborocœtes tasmaniensis*, Tasmania. Fig. 3, *Elosia nasus*, Brazil. Fig. 3^3, *Hylodes oxyrhynchus*, West Indies. Fig. 4, *Grypiscus umbrinus*, Brazil. Fig. 6, *Calyptocephalus gayi*, Chili.

RANIDÆ. — Fig. 3^{-1}, *Ranula chrysoprasina*, Costa Rica. Fig. 3^1, *Rana oxyrhyncha*, South Africa. Fig. 3^2, *Rana agilis*, Europe. Fig. 3^3, *Rana hexadactyla*, India. Fig. 4, *Polypedates quadrilineatus*, Ceylon.

contemporary types as in the Batrachia Anura, but it is none the less universal. The kind of parallelism usually observed is that in which there is only a partial resemblance between adults of certain animals and the young of others.

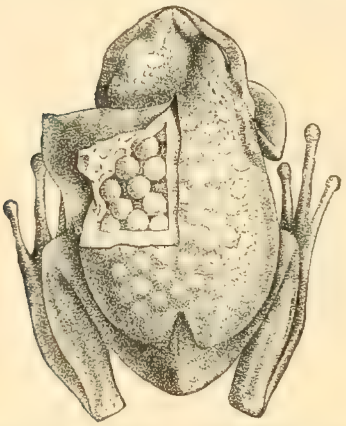


FIG. 191. — *Nototrema marsupiatum* with the brood pouch cut open to show the eggs.

The metamorphoses of these animals have been already referred to, and further details on the subject will be found under the heads of the respective species. I will only note here that while the majority of the Anura undergo a complete metamorphosis, a few pass through the branchial stage while still in the egg (*Hylodes martinicensis*), and other forms carry the young in various ways until this period is passed; (*genera Pipa*, *Nototrema*, *Opisthodelphys*).

SUB-ORDER I. — AGLOSSA.

There are two families of this sub-order, one of which has no teeth — the Pipidæ, and the other has teeth in the upper jaw — the Xenopodidæ. In both of them the vertebræ are opisthocœlous; that is, they are ball-and-socket jointed, with the ball in front and socket behind. The longitudinal epi-

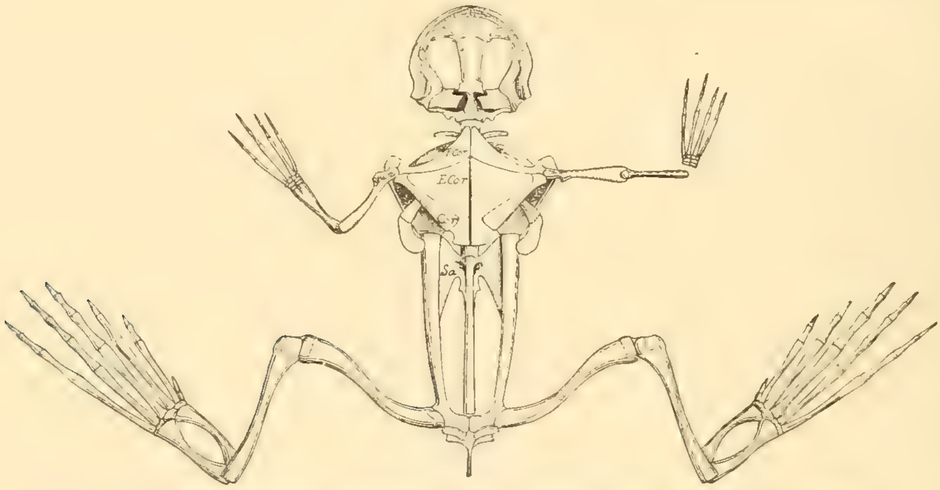


FIG. 192. — Skeleton of *Xenopus*: *cor*, coracoid; *ecor*, epicoracoid; *pcor*, precoracoid; *sa*, sacrum.

coracoid cartilages of opposite sides are distinct, but do not overlap as in Arcifera. The sacral transverse processes are much expanded, and are coössified with the coccyx (Fig. 192). The larvæ differ from those of other Anura in having two branchial openings (*spiracula*), one on each side.

The family PIPIDÆ has the skull completely ossified. It includes but one genus, *Pipa*, which is only known as existing in South America. The sole species, *Pipa americana*, is of rather large size, and of exceedingly depressed form. The terminal phalanges are pointed, and the ends of the fingers terminate each in four dermal

appendages. There are dermal flaps around the upper lip, and the eyes are minute. The feet are broadly webbed. The color is leather brown, paler below, with sometimes a black stripe along the middle of the belly.

The habits of this extraordinary animal during the reproductive season are well known. The eggs are transferred by the male to the back of the female, to which they adhere, and where they are impregnated; their presence excites increased activity in the skin, it thickens, and is gradually built up around each egg, which it at length nearly encloses in a well-defined pouch; this process of investment has been compared by J. Müller and others to the inclusion of the mammiferous ovum by the deciduous membrane of the uterus. The opening which is left after the pouch is

FIG. 193.—*Pipa americana*, Surinam toad.

formed is at length closed up by an operculum, and thus the egg is shut off from all direct communication with the air.

Professor Wyman describes the growth of the young *Pipa* as follows: "Of the eight specimens which I have examined, two were destitute of eggs in the back, and the skin of these presented a uniform surface throughout, covered, as is usual, with conical papillæ. One of them I ascertained by dissection to be a female, the ovaries being well filled with eggs. In the backs of all the others, ova existed in different stages of development, the number of egg-sacs varying in different specimens from forty to one hundred and fourteen.

"The eggs are quite remarkable, when compared with those of other Batrachians, for their great size, the yelk alone measuring one fourth of an inch in diameter. In almost every instance, on removing the operculum, the embryo, however small, was found just beneath it, and thus occupying a position on the yelk which has the nearest proximity to the air.

"In the earlier stages . . . the head is broad and flat, the cerebral vesicles are easily detected, the lateral portions not having united on the median line; the eyes were prominent and black; the spinal canal was closed, and the ventral laminæ were just beginning to extend upon the upper surface of the vitellus; the arms consisted of pyriform processes from anterior portion of the trunk, but the legs consisted of oval masses entirely disconnected with the parts surrounding the vertebral column, and seemed to have an independent centre of growth, and therefore did not bud out from the trunk. In all of the earlier specimens these branchial appendages were visible on each side of the head. The general aspect of the embryo, as it lies extended on the surface of the yelk, reminds us of the larval condition of salamanders and tritons. In a later stage, as exhibited in another series of embryos, the external branchiæ had disappeared; the legs, now united with the trunk, were terminated by an expanded extremity, the rudiment of a foot; the ventral laminæ as represented by the dotted line, extended farther down upon the yelk, but still this last was to a great extent, uncovered; the nostrils were visible, as round terminal depressions, but it was not ascertained if they communicated with the mouth. A small branchial fissure was detected on each side of the neck, and within this, as was shown by slitting open the mouth and œsophagus, there existed on each side a series of fringed branchial arches.

"The most extraordinary feature, however, of this stage was the peculiar change going on in the yelk mass; the whole of the yelk substance was moulded into a spiral coil, and invested with a thin tunic, and thus converted at once into a spiral intestinal canal, the coils of which extend from the sides of the trunk to the most prominent portion of the yelk, and then, changing direction, and occupying the axis of the coil, the intestine passes back again towards the trunk. The whole yelk-mass is therefore moulded into a spiral intestine. In none of the instances which fell under my notice had the final metamorphosis taken place. But Bonnet, Dumeril, and others have observed that the tadpole remains in the dermal sac until its limbs are perfectly formed and the tail has been absorbed; until, in truth, it arrives at the same stage reached by the common toad; when, having finished its aquatic life, to which it is no longer adapted, it leaves the water and seeks its livelihood in a more congenial manner on the land.

"In addition to the unusual circumstances under which these animals are developed, it will be seen that they are objects of especial interest in connection with the general subject of the development of Batrachian reptiles. The first peculiarity which may be noticed is as to the period at which the arms and legs make their appearance. The tadpoles of frogs and toads acquire a comparatively advanced stage of development before any traces whatever of limbs are seen; they leave the egg, increase in size, and after a period (variable in the different species) of weeks or months, the rudimentary arms and legs begin to be found. In *Pipa* they appear before the external branchiæ disappear, and before even the ventral laminæ descend upon the sides of the vitellus. The development of the limbs independently of the vertebral column is an interesting morphological fact.

"That the first trace of a leg is an oval mass, entirely free and detached from the

vertebral axis, goes to show that, whatever view we may adopt with regard to the homology of legs, the pelvis included, they are something superadded to it, and not evolved from it or any of its processes. I have ascertained, by direct observation, that even among frogs, the legs, which appear on each side of the tail in the form of small papillæ, are primarily tegumentary growths, that beneath these there is developed a cartilaginous plate which gradually extends upwards on each side, until it meets with the transverse process of the vertebral column, with which it becomes permanently connected under the form of the pelvis, and at the same time the papillæ are developed into limbs with their continued bones; thus the pelvis, which in the adult seems to be an appendage to the vertebral column, is, in the embryo, an independent structure, just as the tooth is primarily independent of the jaw. In this mode of the development of the legs, we have a temporary analogy to the permanent constitution of the same parts in fishes, in which the ventral fins are never connected with the vertebral column by their pelvic bones, these being confined to the abdominal surface of the body.

"The complete development of the tail adapted to swimming is, under the circumstances, worthy of attention. In the ordinary Ranidæ, the phases of development are in accordance with the peculiar conditions under which the earlier periods of life are passed; their habits are not only wholly aquatic, but they have many of the anatomical and physiological characters of fishes, among which may be mentioned the existence of branchiæ for aquatic respiration, and a broad and compressed tail for aquatic locomotion. The embryos of Pipæ differ from those of other allied genera, in passing through all of their embryonic phases in closed dermal sacks, where they neither breathe by the action of aquatic currents, nor are capable of executing the ordinary locomotive movements; yet, the external branchiæ are developed, disappear, and are replaced by internal branchiæ, and these in turn by lungs; the tail also requires its full development, with swimming adaptations, in the form of muscles and folds of skin, as in other tadpoles, and, after having existed for a certain period, is removed by absorption, without having been once made use of as a locomotive organ. It appears that, in this particular instance, the exigencies of embryonic life do not require the existence of a tail for the purposes of locomotion, and its presence seems to be accounted for only on the supposition of the existence of a preëstablished plan, according to which Batrachians generally are developed; and this plan is adhered to, although the organ may not be used, or not used in the same way as in the other species.

"It is possible that the materials of the tail serve as a store of nutritive substance, though this seems scarcely probable; but, even if this be the case, it is none the less a fact that the part assumes a structure, the adaptations of which have reference to a function wholly different. As regards the existence of branchiæ, I have observed an analogous instance in the embryos of *Plethodon cinereus*, where these organs are developed externally, though the eggs are deposited under a log, and the animal is not aquatic at any period of its life.

"The only other subject to which it is proposed to refer is the growth of the embryo, by which there is formed, at the end of incubation, a larger mass than existed in the egg when it commenced.

"This increase in bulk could have been effected in no other way than by an absorption of materials furnished by the dermal sac, since the existence of an operculum would prevent the entrance of nutritive matter from without. The gelatinous matter which originally surrounded the egg may have contributed something, but still there is growth after this has disappeared. It seems highly probable that the walls of the

pouch secrete the necessary additional quantity to supply all that is required for development. In so far as observation has extended, this is a solitary instance among Batrachians, in which the embryo is nourished at the expense of the materials derived from the parent."

The family Xenopodidæ agrees with the Pipidæ in all important respects, as the structure of the skull, the scapular arch, coössification of sacrum and coccyx, etc. (Fig. 192), but differs in the presence of teeth in the upper jaw. It includes but the single genus *Xenopus*, which is represented by three species of the Ethiopian realm. Its toes are acute, and the feet are broadly webbed for aquatic life. There is a short tentacle below the eye. This is a remnant of the balancer, which characterizes the larvæ. These creatures have, on each side of the head, a long tentacle extending backwards, giving them very much the appearance of a siluroid or cat-fish. The species are of plain colors.

Sub-Order II. — Arcifera.

The Anura of this division fall into nine families, which differ in simple and generally obvious characters. Thus the Bufonidæ and Dendrophryniscidæ have no teeth whatever, and the former family, which includes the true toads, differs from the

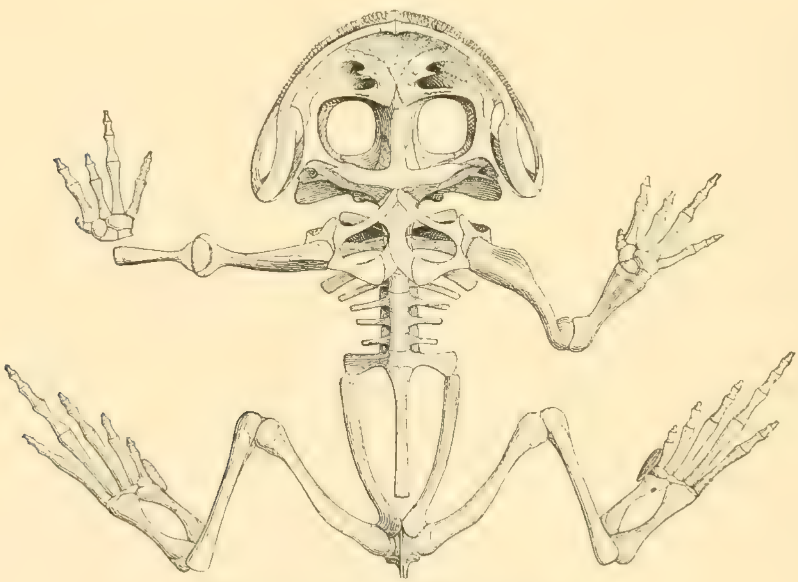


Fig. 194. — Skeleton of *Ceratophrys dorsata*.

latter in having the transverse processes of the sacrum much expanded and flattened (Fig. 192), as distinguished from the subcylindric form seen in the Dendrophryniscidæ. This difference separates several other families also. Five of the remaining families have teeth in the upper jaw only. In one of these, the Cystignathidæ, the sacral transverse processes are cylindric, Fig. 194, and in the four others they are expanded. Two of these differ much from the other two in having the ball and socket of its vertebræ related in a way the reverse of what is seen in all other members of the order, but similar to the structure found in many of the salamanders. That is, the ball is in

front and the cup behind, instead of the cup in front and the ball behind. Of these two families, one, the Discoglossidæ, has short ribs, as in the salamanders, and has a sternum formed of two diverging branches. In the other family, the Asterophrydidæ, there are no ribs, and the sternum is not divided. In the other two families the habitus is very different, since the one, the Hylidæ, passes its life in the trees, and the other, the Pelobatidæ, consists mostly of burrowing subterranean species. In the former, the last or ungual phalanges have a ball-shaped base, from which projects from a notch, a curved, sharp, claw-shaped termination. This supports an expansion of the integuments of a disc-like form, which enables the animals to adhere to any suitable more or less vertical surface. In the Pelobatidæ the ungual phalanges are simple, as in other families. The two remaining families have teeth in both jaws. In one of these, the Amphignathodontidæ, the sacral transverse processes are dilated. There is but one genus and species, which is of South American habitat. The sacral processes are not dilated in the other family, the Hemiphractidæ, which is also a small South American group.

The family of the toads, Bufonidæ, is found in various representatives all over the world, but it reaches its greatest development in the tropics. A few weakly forms with imperfectly ossified skulls occur in Australia, and in Mexico occurs the genus *Rhinophrynus*, which is remarkable for the great compactness and strength of its ossification. The *Rhinophrynus dorsalis*, the only species, is of subterranean habits, and its powers of excavating the earth are largely dependent on the large shovel formed by the projecting horny-sheathed cuneiform bone of the hind foot. Of ninety-two species of Bufonidæ, the genus *Bufo* includes seventy-seven. The largest species is *B. marinus* of tropical America, which not unfrequently is eight inches in the length of the head and body. Some of the *Bufones* have the head marked with bony ridges, and in the *B. typhonius* these are developed into elevated crests, giving the animal an extraordinary appearance. Some species are furnished with a shovel for digging, as in *Rhinophrynus;* such is *B. compactilis* of Mexico. The common species of the eastern United States is *B. lentiginosus*, which has several varieties. The typical form is found in the Gulf States. The two bony crests which form the eyebrows terminate each in a rounded knob. In the form which is found in the middle, northern, and western states, the sub-species *americanus*, these knobs are wanting. A peculiar variety, *B. fowleri*, occurs in Massachusetts and in the Dominion of Canada. The crests in this form are thickened behind, and nearly or quite join, forming an osseous boss on the skull. The voice and habits of this form are said to be quite different from those of the *B. americanus*, which is found in the same region.

The common toad of the middle states is a well-known inhabitant of gardens and other localities where insects abound. Its habits are crepuscular, and its quiet though sudden movements in the evening are familiar to every dweller in the country. It is one of the first of the Batrachia to enliven the spring with its note, as it rests in the water during the process of depositing its spawn. Its voice is a sonorous urr-r-r-r-r, and the pitch varies with the individual toad. It prolongs its singing period well into the summer, and its music in retired ponds and swamps, as darkness creeps over the face of nature, is both weird and somnific. The eggs are deposited in a single line in the central tube of a long rope of a transparent albuminous substance, which assumes a coiled shape on the bottom of the water where it is deposited. The tadpoles retain their early black color, thus differing from those of most of our Anura.

They undergo their metamorphoses while of smaller size than most of the native Anura. When they leave the water, they make long journeys in every direction, hiding themselves during the day. Should rain fall, they emerge from their hiding-places, and appear at times in great numbers, thus giving rise to the supposition that they have fallen with the rain.

A very small species of toad, *Bufo quercicus*, is found in the south-eastern part of the United States from North Carolina to Florida inclusive. The largest North American *Bufo* is the *B. boreas* of the Pacific fauna, which is sometimes nearly as large as the *B. marinus*. A small species of the upper Missouri region (*Bufo dipternus*) has two well-developed tarsal shovel-spurs, like some species of the South American genus *Paludicola*.

There is a greater range of ossification of the skull in Bufonidæ than in any other family of Anura. Thus in the Australian *Chelydobatrachus* there is not only a

FIG. 195. — *Bombinator igneus*, Unke, Feuerkröte.

frontoparietal fontanelle, but the ethmoid bone is unossified above. (See page 320, Bufonidæ, Fig. 1.) In the Australian *Pseudophryne* and the European *Epidalea*, the ethmoid is complete, but the fronto-parietal fontanelle remains. *Epidalea calamita* is the natterjack toad of the English, and is confined to western Europe. In *Bufo* the skull is completely ossified, but the epidermis of the skull and often the derm, are free. In the next stage the ossification involves even the epidermis (pl. cit. Bufonidæ, Fig. 6), and over-arches the temporal fossa and muscle. This is the character of the genus *Peltaphryne*, of which *P. peltacephala* of Cuba is the type. The genus *Cranopsis* of Central America has the same character, with the addition of imperfect auditory organs. The typical species, *C. fastidiosus* is found in the high Cordillera

of Costa Rica. In the genus *Otaspis* a greater extent of ossification is seen than in any other. It adds to the characters of *Peltaphryne* a complete enclosure of the tympanic membrane posteriorly, a character not found in any other Batrachian. The *O. empusa* (page cit. Bufonidæ, Fig. 7) is Cuban.

The family of DENDROPHRYNISCIDÆ includes a few species from the Andes of South America.

The family of the DISCOGLOSSIDÆ belongs to Europe, with one species in New Zealand. The latter is the *Liopelma hochstetteri*, and is the only batrachian known to inhabit that island. The family is an interesting one, not only on account of its peculiar structure, but because it includes some remarkable fossil representatives. These belong mostly to the genus *Palæobatrachus*, and many specimens of three or four species occur in the miocene lignite beds of Rhenish Prussia. *Discoglossus* has one very variable species from southern Europe. In *Bombinator* the organs of hearing are defective. The single species, *B. igneus*, is the Feuerkröte of the Germans, and is very common in some regions of Europe and temperate Asia. The colors of its upper surface are obscure, but the belly is varied with bright crimson. It is aquatic, and utters a singular smooth and high-pitched cry. There are two species of *Alytes*, one of them from Spain, the other (*A. obstetricans*) from middle Europe. The latter is the Geburtshelferkröte of the Germans, and is distinguished by the way in which the male carries the eggs. As in the American salamander, *Desmognathus fuscus*, they are laid in a long albuminous string. This the male places on his back, winding it about the bases of his legs for security. The albumen dries, forming a thread, which remains until the eggs are hatched. The *Alytes obstetricans* is common in dry places near Berlin. Bones of an extinct *Alytes* occur in the miocene coal of Prussia. It has been observed that the males of the species of this family grasp the female, during copulation, round the waist, instead of round the axillæ, as in other Anura. The tadpoles also differ from those of all other families in having the branchial opening on the middle line below, instead of on the left side.

FIG. 196.—*Alytes obstetricans*, obstetrical toad.

The family of the CYSTIGNATHIDÆ is confined to the Australian and South American or Neotropical faunæ, and is one of the most extensive of the order. One hundred and sixty species have been described, which display a great variety of structure, falling into twenty-six genera. Its range includes forms adapted for burrowing in the earth, or for living on its surface, for climbing the faces of rocks and trunks of trees, and for swimming in water. Many of the genera have incompletely ossified

skulls, and cartilaginous sterna. Of those with complete skulls, but a few (genus *Leptodactylus*, etc.) have an osseous sternum. The species of the Australian genus *Heleioporus* resemble toads. On the other hand, the species of *Leptodactylus*, and still more those of *Pseudis*, resemble frogs. Many of the *Hylodes* resemble tree-toads. Several of the species of *Leptodactylus* (a genus which ranges from Patagonia to northern Mexico) possess remarkable horny excrescences for the purpose of maintaining a firm hold of the female during copulation. There is in *L. pentadactylus* a process of the metacarpal bone of the thumb, which is directed inwards, and is capped with horn. On each side of the breast is a horny shield, which terminates in three sharp points. The *Cystignathus ocellatus* is the largest species of the family,

FIG. 197. — *Chorophilus ornatus.*

nearly equalling the *Bufo marinus* in dimensions. The humerus of the male has a high deltoid crest, and in the breeding season the muscles of the arm of the male become greatly developed.

The species of *Lithodytes* inhabit rocky regions. They are especially abundant north of the Isthmus of Panama. One species, *L. latrans*, is found in western Texas. It lives in the fissures in the limestone precipices, and is supposed to deposit its eggs in pools of rain-water, which are caught in caverns and holes. At such times its loud voice issuing from the rocks is a cause of much speculation to the people, who cannot detect its source. They usually ascribe it to a species of lizard (genus *Gerrhonotus*).

Species of *Hylodes* occur in all parts of tropical America. The *H. martinicensis* is one of the most abundant frogs of the West Indian islands. Although furnished with digital dilatations, it lives on the ground, concealing itself in pairs beneath various objects. On the approach of rain it is very noisy, and its cry is supposed by the negroes to be uttered by lizards which they see in the same localities. The curious fact has been observed in Guadaloupe by Bavay, and by Bello and Gundlach

in Puerto Rico, that this species passes its metamorphosis within the egg, and issues from it fully developed, although of small size. The eggs are laid between the leaves of living plants, or under leaves or stones on the ground. Sometimes the frog sets on them. They are quite transparent, and in about eight days the embryo is visible. The form of the embryo is much like that of a salamander, as it is elongate, and with limbs of nearly equal length. Bavay saw minute branchiæ, which the other observers did not report. The young left the egg in about fourteen days, wearing a tail, which was absorbed in a day.

In *Calyptocephalus*, the cranial ossification is more extensive than in any other genus of Cystignathidæ, as it over-arches the temporal fossa. The feet are webbed. The type, *C. gayi*, is a rather large green species which inhabits Chili.

The species of *Ceratophrys* are of toad-like form, and frequently have dermal processes of the eyelids and muzzle, which give them a strange appearance. Some of them have osseous plates in the integument of the back. In *Telmatobius*, the auditory organs are defective. The species all live at high altitudes in the Andes. One of them is said to be a vegetable feeder, and to be subaquatic, searching for food

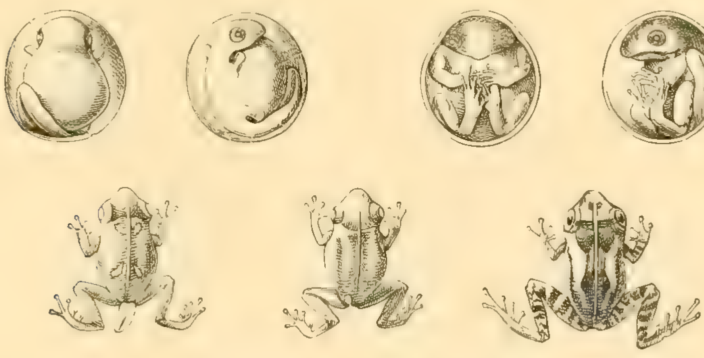


FIG. 198.— Development of *Hylodes martinicensis*.

on the bottom of the elevated lake of Titicaca. The species of *Pseudis* are found in Brazil and southwards. They belong to a section of the family where the web of the hind foot extends up between the external metatarsal bones. This occurs elsewhere among the true frogs, but in most other Anura these metatarsals are closely bound together. In the *P. paradoxa* the metamorphosis is more protracted than in any known Anuran. The larvæ reach a size equal to, if not exceeding that of the adult, and retain their large tail while the legs are well developed.

The Pelobatidæ are nearly all subterranean in their habits. There are two sections of the family, the one inhabiting Europe, and the other North America. In the former, the sacrum is coossified with the coccygeal style, thus giving a peculiar T-shaped bone. In the latter, these bones are separate, as in other Anura. Both groups display a remarkable range in the degree of ossification of the skull. In the lower forms there is a large fontanelle on the top of the skull; and succeeding genera see this opening covered by smooth bone. In the next type, the bones of the skull are covered by a rough exostosis; then the skin is filled with this ossification, and, finally (genus *Cultripes* of Europe) the temporal muscle is covered with a bony,

arched roof. In North America the genus *Spea* occupies the lowest position. Its species inhabit the western part of the continent, extending to the valley of Mexico, and are remarkably adapted to an arid climate by the great rapidity of their metamorphosis. On the occurrence of a rain during the summer, they emerge from their subterranean retreats, and deposit their eggs in the pools which collect in the dry arroyas, and in the low lands. Here the larvæ are soon swimming about, and early acquire their legs, so as to escape from the muddy fluid as soon as possible. When completely changed, the young of the *Spea hammondii* are not larger than those of the common toad. I made the following observations on the *S. bombifrons* which I found in Idaho Territory in a region rather less arid than that inhabited by *S. hammondii*:—

"In Idaho, near latitude 43° 30′, is situated a body of water known as Market Lake. Its extent is variable, for it is said to be dependent for its water supply on the overflows of the Snake River, which is a few miles distant to the eastward. An old channel leads from the river to the lake, giving probability to the statement. At the

FIG. 199.—*Ceratophrys fryi*, from Brazil.

time of my passage through the region, the water was unusually high, for a portion of the stage road, with parts of numerous telegraph poles, was submerged. The lake appeared to be about ten miles long by six in width. The country surrounding it is arid, and the sand which represents soil rests on a basis of lava. The stage halted for a short time to enable me to examine the shore of the lake. I found it to be lined with a wind-row of grasshoppers (*Caloptenus spretus*) which had fallen into the water and been washed up, some living, others dead. Among them I found numerous large fat larvæ of *Spea bombifrons*, occupying small spaces which they had cleared, quite out of the reach of the water. Their limbs were nearly fully grown, while their tails had suffered no absorption, and their jaws were toothless and cartilaginous; some quite larval in form, others with wider gape. They were engaged in eating the grasshoppers, and I detected several specimens with the entire insects in their mouths. In some instances, the grasshoppers' bodies were too large, and projected from their mouths. These precocious larvæ were evidently air-breathers, and hopped about,

presenting a curious appearance as they dragged their large tails after them. I found some adult specimens of *Amblystoma mavortium* also along the water's edge. These observations were made on the 11th of August, 1876."

The American species of this family are exceedingly noisy at the time of depositing their eggs. This takes place in spring, generally in temporary pools, even in regions where water abounds. They frequently appear near inhabited places. Thus I have heard the vacant lots of Santa Fé, New Mexico, resound with the cries of *Spea hammondii*, and similar places near Philadelphia vocal with the *Scaphiopus holbrookii*. A pool near a hotel on Pyramid Lake, Nevada, was in an uproar at the time of my visit in July, 1882, with *Bufo boreas* and *Scaphiopus intermontanus*, — the voice of the latter quite in the ascendant.

The *Scaphiopus holbrookii* appears quite suddenly and disappears equally so. During the remainder of the year it is concealed underground, and is therefore rarely seen. Dr. Abbott thus describes its habits.

"In a sink-hole in a dry upland field near Trenton, New Jersey, on April 10, 1884, there suddenly appeared a large colony of hermit spade-foot toads (*Scaphiopus holbrookii*), which, by their remarkable cries, attracted the attention of every one passing by. So unlike the cries of any other of our batrachians were their utterances, that all who heard them were attracted to the spot, and wondered, when they saw the animals, that so great a volume of sound could issue from so small an animal. One need not wonder, however, on this point, if they will but examine the development of the animal's vocal cords. The machinery for producing sounds equal to an ordinary steam whistle is apparently contained in the throat of this rare and curious batrachian. Holbrook, in his diagnosis of the genus *Scaphiopus*, refers to the 'subgular vocal sac' of the males; but it must not be inferred that the females are voiceless. That they are not so noisy is probable, but, occasion requiring, they can readily make themselves heard.

"These spade-foots remained in the shallow waters of this sink-hole until April 15, when, the weather becoming considerably cooler, they as suddenly disappeared as they had come. In May, 1874, these toads appeared in like manner in the same locality, remained but a few days, and were gone. In the intervening ten years not a specimen was seen or heard, although careful search annually was made. I supposed, when they appeared in April of the present year, that they spawned previous to their sudden disappearance, but I neglected to investigate the matter in consequence of press of work in other lines of investigation. The spade-toads were soon forgotten. The wealth of bird life that came trooping in from the south during May, and their subsequent nesting, occupied my thoughts and were the prominent objects sought during my daily rambles.

"It was not long, however, before the spade-foots again became the prominent feature of the fauna of the neighborhood. During the night of June 25-26 a violent northeast storm arose, and rain fell in torrents. The sink-hole, which for weeks had been nearly dry, was again flooded, and on the afternoon of the 26th was literally alive with these rare toads. Sitting upon every projecting stick or tuft of grass, or swimming with their heads above the surface of the water, were spade-foots by the hundred, and every one apparently uttering those shrill, ear-piercing groans that only these batrachians can utter. Not only during the day, but all night, their cries were kept up. The following day there was no abatement, but during the night the sound decreased. On the morning of the 28th not an individual was to be seen or heard.

"During this brief interval these animals spawned, the eggs being attached to blades of grass and slender twigs. These eggs hatched on the 2d of July, and a large series were gathered a week later. To return to the eggs. During the time that intervened from the laying of the eggs until I gathered specimens of the tadpoles, there occurred four moderately heavy showers, so that the water in the sink-hole at no time disappeared, but was much below the level that it reached during the protracted rainfall of June 26. Very much, therefore, of the spawn that was laid was high and dry for from two to four days before hatching, and I suppose was destroyed.

"On the evening of July 9, I found the water in the sink-hole confined to a few very shallow pools of limited area, and in these pools were a few hundreds of *Scaphiopus* tadpoles. In comparison with the abundance of eggs seen June 26, and of young seen a week later, it is evident that a large portion of the eggs was destroyed, and a vast number of very young tadpoles were killed by the soaking away of the water.

"I have never known any like disparity between the eggs of frogs or common toads, and the young in the tadpole state; and it is at once very evident that if the spade-foot toads habitually or usually deposit their eggs in temporary pools, then we have an obvious reason for the positive rarity of the animal, as apparently it is the rule, rather than the exception, for the egg to be destroyed or the young perish.

"The tadpoles gathered July 9, which were then seven days old, were curious creatures. At this time the hind legs were well developed, although small, and did not interfere with the animals' natatorial locomotion. The bodies of these young *Scaphiopi* were short, stout, and oval, and, when viewed in the water, deep velvety black; but when closely examined it was found that the two irregularly parallel yellow dorsal stripes, that are so prominent a feature in the coloration of the adult male, were plainly discernible.

"The movements of these tadpoles were not different from that of the young frogs and toads in this stage of their existence. Those that I had in an aquarium moved in companies, as though following a leader, and occasionally one would drop out of the ranks, come quickly to the surface, eject a bubble of air, and dive again quickly to the bottom of the tank. Like all tadpoles they had enormous appetites, and when fed with bits of raw meat quickly attached their sucking mouths to the food offered, and did not remove them, I think, while a particle of blood remained in the mass.

"A week later, July 16, the majority of these tadpoles had acquired their front legs, and the tail had perceptibly diminished in size, but still was used by them when moving through the water. At this time, however, the movements of the animal are far less active than before or soon after, and for a few days, if exposed to the attacks of any enemies, would suffer far more than at any other period of their lives.

"A very curious feature in the growth of these animals is now to be noticed. Of the specimens I had under examination in an aquarium, about five per cent did not progress beyond the condition which all were in July 9. These 'retarded' tadpoles proved to be voracious cannibals. They seized their more matured companions by their tails and legs, swallowing the member, and thus sustained their own lives at the expense of their fellows. They generally killed their victim in the course of twenty-four hours, and often in less time, and then promptly seized another. So blood-thirsty were these few 'retarded' tadpoles, that I was compelled to protect the lives of the little hoppers, their brethren, which now, in spite of stumps of tails, sat in

froglike fashion on their haunches, and were in all respects miniatures of the adult spade-foots that in April and June made night hideous with their unearthly cries.

"Having tested several specimens, a few days previously, as to their ability to assume the land-life of adult *Scaphiopi*, by placing them upon damp sand, and finding that they throve fairly well, on the 25th of July I removed the water in the aquarium and put in earth to about an inch in depth, and very carefully smoothed the surface. Upon this the young spade-foots were placed, and in less than one minute many had commenced digging little burrows, into which they disappeared as the excavations deepened. In all respects these burrows were like those made by adult spade-foots, oval in outline, oblique in direction, and generally with the slight angle in the course.

"In twenty minutes all but two, of forty-four specimens, were below the surface of the earth stratum I had placed in the aquarium.

"During this simple series of observations of young *Scaphiopi* in confinement, I watched also the development of those left in the sink-hole. The water there soon was confined to mere puddles concealed in the dead leaves, and before the young had their limbs fully developed, the depth was nowhere sufficient to permit of swimming. Three days in advance of the maturing of my confined specimens, I saw, in a sink-hole, a few individuals which had fairly assumed the land-living, air-breathing stage of existence. Supposing that, like those I had at home, they would burrow in the earth where they were, I did not visit the locality from the 21st to the 31st of July, on which date I made an exhaustive but unsuccessful search for them. Not a trace of either young or adult could I discover. It cannot be said that they were overlooked. My search was too careful and comprehensive for this, and I believe that these spade-foots, both old and young, wander farther from their breeding grounds than is supposed, or else dig far deeper into the earth than a depth of six or eight inches, as stated by Holbrook and De Kay."

The Hylidæ, or true tree-toads, embrace one hundred and seventy-five species, of which by far the greater number inhabit tropical America. About twenty species inhabit Australasia, one species tropical Asia, and one, the *Hyla arborea*, extends from western Europe to Japan. The ball and claw-like character of the terminal phalanges of the toes of the members of this family have been already referred to. There are dwellers in trees found in other families, especially in the Cystignathidæ and the Ranidæ, all of which have flat or disc-like dilatations on the extremities of their toes, like those of the Hylidæ. But the shape of the supporting phalange is different in each case. In the *Hylodes* type of Cystignathidæ it is T-shaped, and in the Ranidæ it is generally Y-shaped. In some members of the Hylidæ the characters are not very well presented, especially in the North American genera *Chorophilus* and *Acris*, which live on the ground, frequently in the neighborhood of water. Some of the species of the typical genus *Hyla* have similar habits, and approach those genera in structure, viz., the *Hyla pickeringii* of North America. Among the arboreal types there is a great range in the ossification of the skull, as I have already shown to be the case in other families. In *Hypsiboas* and *Hyla* there is a large cranial fontanelle, while in *Trachycephalus* the extensive cranial ossification occupies the skin, so that the head is bared and rough on its upper surfaces. This forms an excellent protection against snakes. In the genus *Triprion* this ossification is carried to a great degree. It forms a prominent rim overhanging the mouth all round, projecting in front like the brim of a cap in one species, the *T. petasatus* of Yucatan, or like a spoon in another, *T. spatulatus* of West Mexico. This genus is also entirely

exceptional in having a longitudinal row of teeth on the roof of the mouth, on the parasphenoid bone. Most of the largest species of this series belong to the genus *Hypsiboas.* This is characterized by the presence of a thumb, in which the last phalanges are co-ossified into a curved spine of dense translucent bone, with a very sharp apex. This is concealed in a sheath of skin, but readily penetrates an object against which it is pressed. This is another arrangement for enabling the male to maintain his hold on the female during the season of breeding.

In the genus *Phyllomedusa*, the middle toes of both feet are reduced in size exactly as in some genera of African lemurs (*Arctocebus*, etc.), so that the external toes oppose

FIG. 200.—*Nototrema marsupiatum.*

each other. This is an adaptation to the habit of seizing a limb round it, a mode of securing a hold different from that which prevails in the family generally, where the toes are attached to flat surfaces by adhesion of their terminal discs. Accordingly the discs are small in *Phyllomedusa.* This genus is connected with the central form *Hyla* by intermediate forms, especially by the genus *Agalychnis.* Of the ninety-five species of the genus *Hyla*, the largest are the *H. dolichopsis* of New Guinea, and the *H. vasta* of the West India island of San Domingo. The head and body are five inches long in both. They are exceeded in dimensions by the *Phyllomedusa bicolor*, which occasionally reaches seven inches. The smallest *Hyla* is the *H. pickeringii*, which is an inch and less in length. The common *Hyla* of the

United States is the *H. versicolor*, and the common and only European species is the *H. arborea.*

The *Hylæ* of North America lay their eggs in the water, on some fixed body, as an aquatic plant, in smaller packets than those of the frogs, and not in strings, as do the toads. The young of the *H. versicolor* are gray, and they undergo their metamorphoses while small.

The *Hylella platycephala* of southern Mexico is said to deposit its eggs in the water which accumulates in the axils of the leaves of certain plants of the genus *Tillandsia*, and to undergo its metamorphosis high above the ground. The species of *Nototrema* and *Opisthodelphys* have another method of carrying their eggs. They place them on their back, and in a pocket formed by the infolding of the dorsal skin. This is forced upwards from a point on the coccyx, in the manner of the finger of a glove, and expands so as to cover, when distended with eggs, almost the whole dorsal region, see Fig. 191. In *Nototrema marsupiatum* of Peru, the young leave the pouch while tadpoles. In *N. testudineum* and in *Opisthodelphys ovifera*, they pass through their entire metamorphosis in this singular position. In the latter species the branchiæ of the larvæ are of a peculiar bell-shape.

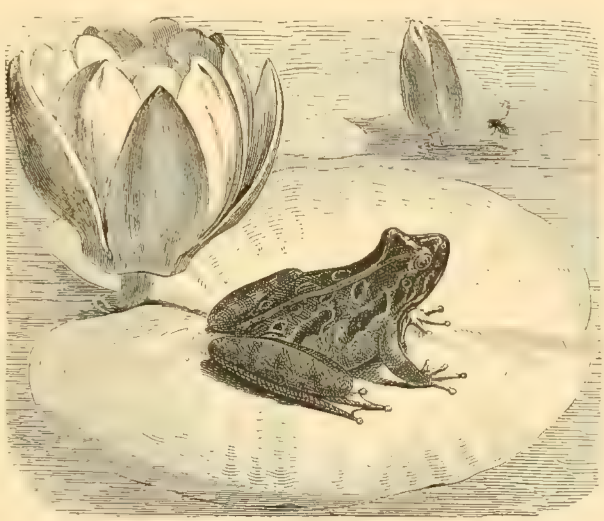


FIG. 201. — *Acris gryllus.*

The species of Hylidæ are noted for their loud and varied voices. The first note of spring in the United States is the shrill piping of the *Hyla pickeringii* in the swamps. If these little animals are imprisoned at this time in a vessel, the deafening loudness of their voice can be appreciated. Near the same time the rattle of the *Acris gryllus* is heard from the same localities. A similar but weaker sound can be produced by violently rattling clay-stone pebbles together. Later in the season, in similar localities of a generally more sandy character, the voice of the *Helœcetes triseriatus* is heard. The note of this frog may, in fact, be heard all summer in swampy ground, which it never leaves for the trees. It may be imitated by scraping a coarse toothed comb, and at the same time lifting it from some confined space, as of a pitcher, to its mouth. It is, in other words, a rattle with a rising inflection at the end, more deliberately uttered than that of *Acris crepitans.* In the spring, especially when it rains, the country is vocal in the evening with the clear, loud, trilled rattle of the *Hyla versicolor.* This species also continues its vocalization at intervals through the summer, mostly in the evening. The *Acris* and *Helœcetes* may be heard during the day as well. In the autumn the tree-frog that is most frequently heard is *Hyla pickeringii.* Its voice is less vivacious than in the spring, and its lonely pipe in dry woodlands is always associated with golden-rods and asters and falling leaves.

The Mexican *Hyla arenicolor* is said to utter a cry much like the bleating of goats. The voice of the *H. faber* of Brazil is loud and metallic, resembling strokes on an anvil. The noises of the Brazilian forest at nightfall are largely due to the species of Hylidæ that inhabit that country.

The colors of the Hylidæ are often brilliant, and are generally changeable in accordance with the surfaces on which the animal rests. The *Hyla versicolor* presents a

FIG. 202. — *Hyla palmata*, from Brazil.

marked instance of metachrosis or color-change. When on the trunk of a tree, it may be a dark brown, resembling the bark, or a very pale gray, representing a lichen. When placed among leaves it becomes a bright green. The species of *Acris* and *Chorophilus* can undergo similar changes. An *Acris crepitans* may be studded with brilliant green spots, or have a green dorsal band, or it may be uniform dusky, or have a rufous dorsal band. The species which live among foliage and flowers are often brilliant in their hues. Thus *Hyla pulchrilineata* of San Domingo is green

with yellow longitudinal stripes. *Scytopis aurantiacus* is gamboge yellow. *Hypsiboas punctatus* is spotted with pink. *Hyla marmorata* is painted like a harlequin in gray, black, and yellow. The species of *Phyllomedusa* are often of the finest colors. The *P. bicolor* is green above and pale purple below, with white purple-edged spots on the sides. In the *P. tomoptemus* these spots are replaced by purple cross-bands. In the *Agalychnis callidryas* the colors are green and blue above, and gamboge-yellow below, with vertical bands of citron yellow on the sides. In the rough-headed forms the colors are plainer. The species of *Triprion* live among rocks, and their colors are inconspicuous.

The typical genus of the Amphignathodontidæ, *Amphignathodon*, is very peculiar. It resembles the Hylidæ in form, and is arboreal in habits. It has a dorsal pouch, which is, no doubt, used, like that of the genus *Nototrema*, as a receptacle for eggs. The only species, the *A. guentheri* inhabits the same region, *i. e.*, the tropical Andes.

The Hemiphractidæ include some forms in which the cranial ossification is remarkably developed. This forms a kind of helmet, which develops in some of the species (*Ceratohyla bubalus*, for instance), into processes and crests. In *Amphodus* there are, besides mandibular teeth, teeth on the parasphenoid bone, the only instance of this structure known in the Anura, outside of the genus *Triprion*. Its toes have terminal dilatations as in the tree frogs. The only species, *A. wuchereri*, is from eastern Brazil.

Sub-Order III. — Gastrechmia.

This sub-order is represented by but one family, the Hemisidæ, and by a single well-defined genus, *Hemisus*. The species, of which but two or three are known, are of subterranean habits, and have a general resemblance to those of the genus *Rhinophrynus* of the Bufonidæ. The head is similarly small and with acute muzzle, and the body short and thick. *H. guttatum* is from South Africa, and *H. sudanense* from tropical Africa. The family is toothless.

Sub-Order IV. — Firmisternia.

Of the five families of this sub-order, three are toothless, and two have teeth in the upper jaw only. Of the toothless families the Dendrobatidæ have cylindric sacral processes, and the Phryniscidæ and Engystomidæ have them dilated. Of these two, the former has a clavicle and precoracoid, while they are absent in the latter. They are also present in the toothed families, which only differ from each other in the form of the sacral transverse processes. In the Dyscophidæ these are dilated, and in the Ranidæ they are cylindric or nearly so.

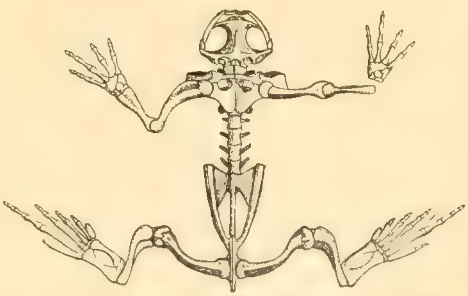


Fig. 203. — Skeleton of *Breviceps gibbosus*, of South Africa, from below.

The Dendrobatidæ belong exclusively to tropical continental America, and to Madagascar, a distribution nearly paralleled by some other vertebrates, as the boas and the Iguanid lizards. The species are not numerous, and they all have digital dilatations, supported by T-shaped phalanges. The species of *Dendrobates*, which are all American, live on the ground.

The PHRYNISCIDÆ are found in tropical America, Malaysia, New Guinea, and Madagascar. Of twenty-two species, sixteen belong to tropical America. Species of *Phryniscus* are found from Buenos Ayres to Costa Rica. Some of them are toad-like in appearance, while others are of more elongate proportions; most of them are strikingly or brilliantly colored. The *P. varius* is common in Costa Rica. It is black above, with spots which may be red or green, and these may be confluent over the back, so as to exclude the dark color. The *P. longirostris* has a dermal process on the end of the muzzle. *Brachycephalus ephippium* is a small species which is common in some parts of Brazil. It looks like a small toad, and has a saddle-like bony plate in the integument of its back. It is bright yellow. In the Central American and Mexican genus, *Hypopachus*, we have the short conic head of the genus *Engystoma;* the Malaysian genus *Calophrynus*, and the *Sphenophryne* from New Guinea have the same form. In the single Brazilian species of *Stereocyclops*, we have the same form, but much depressed, so that it resembles an undersized *Pipa*. The skin has an incrustation which thickens it, and the eyeball has an osseous ring surrounding the pupil. It is leather brown, with a narrow white median dorsal line. Its habits are subterranean or perhaps subaquatic.

In the ENGYSTOMIDÆ the range of form is even greater than in the Phryniscidæ. Thus in *Microhyla* the form is often slender, and the feet are webbed for an aquatic life. In *Callula* the form is more robust. Both these genera are eastern and southern Asiatic. The species of *Engystoma* are American, and are of quite small size. One of them inhabits the southern regions of the United States. In the spring it lives in the water, from which it projects its muzzle far enough to utter its very nasal monotonous cry. When alarmed it withdraws itself so quickly and quietly that it is very difficult to discover. In *Xenobatrachus*, which has a single species found in New Guinea, the dentition is peculiar in the presence of a single long tooth on each palatine bone. The species of the tropical Asiatic genera *Cacopus* and *Glyphoglossus* are almost globular in form, especially when distended with eggs. *Breviceps* and *Phrynomantis* of South Africa are distinguished by the very weak ossification of the skull. The latter has digital dilatations, but lives in the ground.

The DYSCOPHIDÆ include but eight species, which fall into five genera. All the species except one from Pegu inhabit Madagascar. Some of them are remarkable for the beauty of their coloration.

The most extensive family of the Firmisternia is that of the RANIDÆ. It embraces two hundred and forty-eight species, which are referred to eighteen genera. This large family is almost excluded from the neotropical and Australian realms, Mexico and Central America being the only part of the former which is furnished with them, except a few restricted types in the northwestern part of South America. They reach their highest development in the East Indies, where many genera and species are found. The family includes a few subterranean species, and numerous aquatic and arboreal forms. We do not meet in this family with the horny processes for securing the attachment of the sexes, found in some of the Cystignathidæ, but the firm structure of the sternum renders the grasp of the male more solid, and also renders the thorax of the female less compressible. In most of the family both the anterior and posterior sternal elements (manubrium and sternum proper) are furnished with an osseous style. In the South American genus *Prostherapis* the sternum is membranous and rudimentary, but the manubrium is ossified, while in *Colostethus*, of the same region, both manubrium and sternum are membranous or wanting. Both of

these genera have the digital dilatations apparently like those of tree frogs, but they are supported by T-shaped phalanges, as in *Hylodes*. In *Prostherapis* they are divided into two lateral lobes by a longitudinal fissure on the upper side.

The Asiatic and African types of arboreal Ranidæ have the dilatations of the toes supported by Y-shaped phalanges, with the sole exception of the African genus *Hylambates*, which have the ball and claw form of the Hylidæ. The largest and most brilliantly colored of the old-world tree-frogs belong to the genus *Rhacophorus*. In some of the species of the Malaysian islands the webs connecting the fingers and toes are so large as to form, when extended, parachute-like supports to the animal when leaping from tree to tree in the air. A related genus is the African *Chiromantis*, where the toes of the hand are opposable, two against two. *Ixalus* is a genus widely distributed in Asia, which includes generally small species, all without teeth on the roof of the mouth. *Hyperolius* is a somewhat similar genus, also without vomerine teeth, which is distributed everywhere in Africa where there is vegetation. Many of the species are brilliantly colored.

FIG. 204.—*Rhacophorus reinhardtii.*

There are over one hundred and ten species of the genus *Rana*. Some of them have digital dilatations, and are arboreal in their habits. Others have smaller dilatations and are terrestrial. The typical species are aquatic, or live on the edge of the water, in which they take refuge on the approach of danger. Most of the species are remarkable for the length of the leaps they can make, and the aquatic forms are equally expert swimmers. The largest species is the North American bull-frog, *Rana cates-*

biana, in which the head and body occasionally attain a length of eight inches. The common species of Europe are the *Rana esculenta* and the *Rana temporaria.* The former is a green species with numerous glandular ridges of the dorsal integument. The *R. temporaria* has but two dermal ribs, one on each side of the back, and is of a pale brown, more or less marked with dark brown. It has a black patch on the side of the head, which includes the tympanic drum. It has a wide distribution, extending, under varietal forms, to Japan, California, and the eastern United States. In the last named region it is the sub-species *Rana silvatica* of American naturalists. It differs from the other American *Ranæ* in its avoidance of water, except during the

FIG. 205.— *Rana temporaria.*

breeding season, and in its preference for dry woods. There its light brown colors readily conceal it among the fallen leaves. It takes enormous leaps, and is difficult to catch on that account.

There are five species of Rana in the eastern United States, including the *R. silvatica*, which represents the *R. temporaria.* One of these is the *R. halecina.* Its colors vary from dark olive to bright green, and its upper regions are always marked with brown spots which may or may not be light bordered. It has several rows of dermal

folds on the dorsal regions. It has a very wide geographical distribution, extending from the northeastern United States as far as Guatemala. It presents two well-marked varieties. The true *R. halecina* is found along the Atlantic seaboard, in the swamps on the borders of the rivers and estuaries. It is of a dark olive color, and has small round brown spots, not light bordered. Its muzzle is more acute. The other variety, *berlandieri*, is found inland in the United States and extends to Central America. It reaches a larger size, and has a more obtuse snout, and is a bright green above with larger light-bordered spots. *Rana palustris* is allied to *R. halecina.* It is confined to the eastern United States, and extends its wanderings further from water and higher in the mountains than that species. It is of a light brown, and has two rows of large, dark-brown, subquadrate spots on the back between the dermal folds of the sides. It has no dermal sacs on the sides of the throat, which are such a marked feature in the *R. halecina.* The common green-frog of cold springs is the *Rana clamata.* It is distinguished by the enormous size of its ear-drum, the two dermal ridges one on each side of the back, and by the rather narrow palmation of the hind foot. In the bull-frog, *R. catesbiana*, the ear-drum is not so large, there are no dermal folds on the back, and the foot has a wider web. It prefers muddy banks and the edges of mill-dams and lakes as its abode.

The voices of the *Ranas* are not as musical or varied as those of the Hylidæ. The *R. sylvatica* is the most silent species. The voice of the *R. palustris* is a low, strained, prolonged croak, as though woven goods were giving way. In the spring the swamps resound with the 'chock, chock' of the *Rana halecina*, which, while not very loud in each individual, when performed by a chorus of thousands, creates a deafening din. The more solitary *R. clamata* is usually heard to utter a 'chung' to a small audience in a small spring. The sonorous roar of the *Rana catesbiana* is well known to every one who dwells in the country near a mill-dam. Several of these animals will awaken the silence of a hot summer evening with notes calculated to disturb the repose of the superstitious. The comparison with the voice of a bull is not very inaccurate.

The North American species of *Rana* deposit their eggs in large more or less globular masses attached to sticks, plants, etc., in the water. Some of the arboreal species of Ranidæ adopt other modes of securing their reproduction. The *Chiromantis guineënsis* of West Africa deposits its eggs in albuminous masses in bunches of leaves of trees, to which they readily adhere. During the dry season these masses become quite hard, but on the advent of the rains they become soft, and fall to the ground below. As the mother frog is careful to place the eggs in leaves which are suspended over a watercourse, they soon reach the proper element for their development.

The tadpoles of frogs are very voracious, and feed on flesh of such animals, living or dead, as they can masticate with their feeble horny jaws. They are most excellent preparateurs of skeletons, and have furnished the most delicate specimens in perfect preservation, as was long ago demonstrated by Professor Baird.

In the dry regions of South Africa are several species of *Rana* which live in holes in the ground, only issuing after rains. Such species have a shovel on the hind foot, like the species of Pelobatidæ, but this character shows so many stages of development in the different species that they cannot be separated from the genus *Rana.* One of them, the *Rana adspersa*, reaches a large size. In Central and South America there is a genus allied to *Rana*, but which differs from it in having the ethmoid

bone unossified above, so that it forms only a half-ring instead of a ring. This is the genus *Ranula*. Three species are found on the Amazon, and a very elegant one, the *R. chrysoprasina*, occurs in Costa Rica, see plate cit. Ranidæ, Fig. 3.

A remarkable Asiatic genus is *Oxyglossus*, which has the tongue angulate behind. In nearly all other Ranidæ the tongue has two processes separated by a deep notch behind.

The gradation in the ossification of the skull is not so great as in some of the other families of Anura. Thus no genus has a frontoparietal fontanelle, and the ossification does not extend so far on the other hand as to overarch the temporal fossa and muscle. The range is seen first in the completion of the ethmoid bone above, and then in the extension of the prefrontal bones towards each other on the middle line, (see pp. 272, 273, Ranidæ, Figs. 3^{-1}, 3, 3^2, 3^3). At the end of the series is the restricted genus *Polypedates*, where the ossification involves the derm of the skull, as in *Trachycephalus* of the Hylidæ, and *Calyptocephalus* of the Cystignathidæ (see pp. cit. Fig. 5). The species of *Rana* with completed nasal bones (pp. cit. Fig. 3^3), and the genus *Polypedates*, inhabit India.

EDWARD D. COPE.

Class VIII. — REPTILIA.

Reptiles are cold-blooded animals which breathe by means of lungs, and generally have the ventricles of the heart but incompletely separated from each other. The body is protected, externally, by scales or armor plates, and the embryos are provided with an amnion and an allantois. A general structure is presented somewhat higher than that of batrachians, and lower than, though strongly resembling, that of birds.

The general form of the body is that of the previous class. The trunk usually plays the chief part in locomotion, while the limbs are either entirely absent, as in Ophidia, or, among the lower forms, are present only as aids in the serpentine movement. To this end the vertebral column is strong and rigid, terminating posteriorly in an elongated tail, and presenting but feebly those regions so distinct in the birds and mammals. All reptiles, however, are not of this low type; the tortoises, several lizards, and many fossil forms have the limbs well developed and the vertebral column more or less differentiated.

Protection from injury with most of the smaller reptiles lies chiefly in resemblance, color, and in the shielded areas of the skin, the outgrowths of which may be from either the dermis proper, as the scale-like ossifications of many lizards, or from the epidermis, as the corneous plates of the crocodiles and turtles. Many serpents and the remarkable lizard *Heloderma* are provided with poison apparatus, which renders a conflict with them of the most dangerous nature. The larger reptiles trust alone to sheer force for protection.

The skeleton is seldom otherwise than strong and bony, and though many fossil forms, as well as the geckos and *Hatteria*, have bi-concave vertebral centra, as a rule the bodies of the vertebræ are concave anteriorly only. Ribs are quite characteristic, — in the serpents being the chief organs of locomotion, and in a few lizards forming the support of the so-called wings. They are often united to a sternum by means of sterno-costal pieces, and in the crocodiles a cartilaginous plate extends from sternum to pelvis, bearing lateral processes which serve the function of ribs proper. The skull is composed of well-ossified bones, the embryonic condition presented by many batrachians being supplanted, and is connected with the axial skeleton by means of a single condyle. The specialized cranial structure presented by the Ophidians is of particular interest, and will be spoken of in connection with that group. The limbs and their respective girdles, though completely absent in most snakes, are generally present and are often highly specialized.

The nervous system is a decided advance on that presented by the previous class. The hemispheres are large, and show an inclination to overlap the portions of the brain posterior to them. The cerebellum exhibits a regular advancement in development, coincident with that presented by the respective representatives of the class from Ophidia to Crocodilia, where avian peculiarities are anticipated.

As to the organs of special sense: In the serpents and a few lower lizards, eyelids are not present. When thus unprotected, the cornea is covered by a crystal-like scale which holds a thin layer of lachrymal fluid. Hearing is of varying delicacy. A

tympanic membrane, with its cavity and eustachian tube, is present in all the forms except the serpents and some footless lizards. The organs of smell are usually well developed, and in some aquatic forms the external nares are provided with valves. The sense of taste is often more or less defective, and its seat is probably not in the tongue alone, but also in special areas of the mucous membrane of the buccal cavity as well.

The jaws of all existing reptiles, excepting the turtles, are provided with small, sharp, often recurved, prehensile teeth, which never serve the office of mastication, but are used to grasp and retain the prey. Teeth may also be on the palatine and pterygoid bones. (The specialized maxillary teeth of the poisonous serpents will be mentioned in connection with that group.) Salivary glands are present in both serpents and lizards, and sub-lingual glands are characteristic of the turtles. The œsophagus is long, capable of great dilatation, and its walls are usually longitudinally folded, though in turtles they are provided with papillæ; it leads into a stomach, transversely placed in Chelonia, though longitudinal in other forms. The intestine, in all save the herbivorous turtles, is short and but little coiled, and ends in the cloaca, which opens externally by a round opening, or in serpents and lizards by a transverse slit.

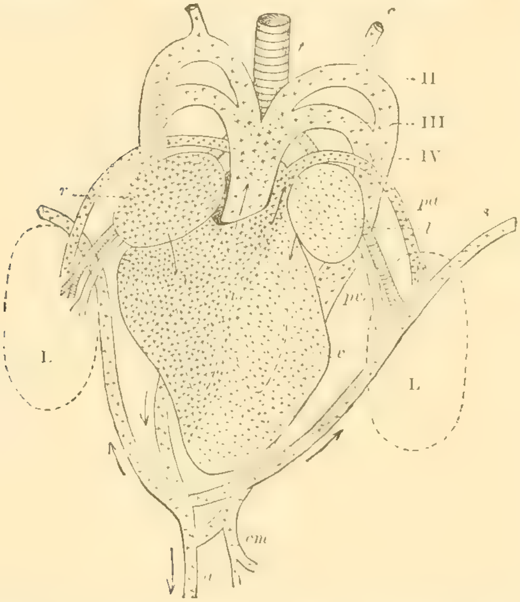


FIG. 206. — Heart of lizard from beneath: the aërated blood indicated by dots, the unaërated by crosses; *a*, abdominal or descending aorta; *c*, carotid artery; *l*, left auricle; *L*, lungs; *pu*, pulmonary artery; *pv*, pulmonary vein; *r*, right auricle; *s*, subclavian artery; *t*, trachea; *v*, ventricle; *I*, *II*, *III*, *IV*, remnants of branchial arches.

Respiration is always performed by means of lungs, and these, except in the serpents and the apodal lizards, are of equal size and of the ordinary structure. Air enters through the slit-like glottis and reaches the lungs by passing down an elongated trachea and bronchial tubes. The ribs play a most important part in breathing; though the rigidity of the carapax and plastron of the turtles compels the members of this group to force the air into the lungs by swallowing it.

The organs of circulation are of particular interest, as they present the several stages of development from that of the batrachians to birds. The right auricle is the larger and receives the systemic, while the left receives the pulmonary veins. The ventricles are only partially separated from each other in the lower forms, and mix, to a greater or less extent, the venous with the arterial blood. Right and left aortic arches are present. The crocodiles, however, have the ventricles separated by a partition, and a structure resembling that of birds is obtained. The right aortic arch and carotids arise from the left ventricle, while from the right ventricle arise a left aortic arch and the pulmonary arteries.

The renal organs are in the hinder region of the trunk, and the turtles and lizards have the urinary bladder appended to the anterior wall of the cloaca, into which also open the genital ducts. The reproductive organs are more or less bird-like, the intromit-

tent organ of the male in the lower forms (Ophidia and Lacertilia) is paired. Though, as a rule, reptiles are oviparous, there are several forms which retain the eggs, until they are hatched, in an enlargement of the ovarian tube. These forms, of which many viperine snakes, as well as the horned toads and some of the apodal lizards, are illustrative, are said to be ovoviviparous.

As to the developmental history of this branch, that of the birds is foreshadowed. The egg is of considerable size, and often contains a supply of food for the growing embryo. By a folding together of the ventral walls of the body, the embryo, though at first lying prone upon the egg, is finally only connected with it by a small peduncle, the umbilicus, through which is drawn the nourishment of the food yolk.

The amnion is a thin membrane enclosing the embryo, which floats in liquid. The allantois is an organ of embryonic life, and performs the office of a respiratory sac. It is appended to the posterior portion of the alimentary tract, and is only met with in those animals which are unprovided with gills, and which do not, on leaving the egg, pass through metamorphoses. These two organs, the amnion and allantois, first appear in the reptiles.

Having now, in a cursory way, examined the general points of structure presented by the various members of the class, an inquiry into its relations can be profitably made; it is here that the real value of paleontology presents itself. By considering the fossil forms, the reptiles are seen to pass imperceptibly into the birds, and the birds are found to reach over, as it were, and greet the reptiles. The dinosaurs were reptiles having the pelvis, hind limbs, and feet strongly resembling those of the ostrich, and some of the bones of the body were supplied with air-cavities. Many were biped, the anterior limbs being extremely small. That they were provided with teeth does not argue their non-avian affinities, for the lower birds, like *Hesperornis*, were well supplied with these organs of prehension. The most remarkable avian peculiarities are presented by members of the highest order, Pterosauria. These flying reptiles had the bones of the fore limbs resembling, to no little extent, those of birds; the neck and head were long; the jaws were sometimes toothless, and encased in horn; the tail was short, and the shoulder-girdle, keeled sternum, and hollow bones carried the resemblance still further. As a result of these resemblances, together with those advanced by the anatomist and embryologist, the birds have been united with the reptiles into a single group, the Sauropsida, the propriety of which arrangement is daily more and more evident.

Although the snakes and a few lizards extend well up into the temperate regions, which is the true home of the turtles, by far the greater number are found in the torrid zone, from which the Crocodilia do not ordinarily wander. As reptiles are animals illy adapted for migration, they endure the cold of winter by passing into a torpid sleep — hibernation, and the enormous heat of the tropical sun by a somewhat similar summer sleep.

Reptiles first made their geological appearance during the carboniferous age, and abounded during the mesozoic, when they were rulers of the air, land, and sea. The classification now generally adopted divides the class Reptilia into eleven orders.

ORDER I. — OPHIDIA.

The characteristics which separate the ophidians or serpents from the other orders of the Reptiles may be briefly stated as follows: An elongated body, protected by scales, which cover, proportionally, much less of the integument than those of the higher reptiles, or those of the fishes, and are so attached as to allow considerable distention of the underlying skin. Limbs are rarely represented, and never except as a pair of posterior rudiments. The tongue, capable of protrusion, is of a dark red or blue-black color. A urinary bladder is not present. Though themselves small in diameter, the ophidians prey on animals of considerable size, and that these may be swallowed whole, the entire structure of the body is specially adapted. The bones of the skeleton, including those of the head, except those whose special function is to protect the brain, are not anchylosed as in most other animals, but connected by ligaments only, allowing the bones considerable individual movement; this specialization is characteristic. In general form the serpents may be regularly cylindrical, there being no external constrictions marking the divisions of the body, as head, trunk, and tail; or the several portions may be very distinctly shown. The head is, in the majority of common snakes, of a depressed, conical shape, though in some it is flat and triangular, or rounded and fusiform. The mouth is generally large and distensible; though in forms like *Typhlops*, it is small, and capable of only limited expansion. The body — or, more properly, the trunk — is ordinarily cylindrical, though many forms have the power of laterally expanding it so as to give them, when viewed from above, the appearance of more than actual size, this habit is possessed by many of the Proteroglyphs, forms like *Naja* having even the bones of the neck specialized to this end. Lateral compression and vertical expansion is characteristic of many innocuous forms, especially so of the tree-snakes. The tail of ophidians, that portion of the animal behind the vent, presents as much variation in general outline as any portion of the body. Though generally round and tapering, in *Silybura* it is short and truncate; in many underground snakes it is rounded, stout, and blunt, performing the office of a lever; and in the sea-snakes (Hydrophidæ) it is compressed and vertically expanded. It may be terminated by a small cap-like scale, as in many common forms, by a short spine, as in some of the Opoterodonta; by a long spine, as in *Acanthophis* and *Pityophis*; by a rattle, as in the Crotalidæ, or it may be simply fusiform and scaled.

In regard to the organs of special sense, the ophidians are somewhat defective. The sense of sight, from observations made by Dr. Yarrow, seems to be more or less imperfect, and though the eyes, being unprovided with lids, must be incessantly on the alert, they are by no means the chief organs for discovering the whereabouts of the prey, the senses of smell and touch here being of chief value. Younger snakes have the eyes proportionally larger. The sense of hearing is dull, so much so that "as deaf as an adder" has become proverbial. There are no external organs of hearing, and it is probable that reptiles feel the jar produced by an approaching animal rather than that they distinctly hear it. The sense of smell is more acute, and by it the animals find their food, as well as their mates; many are known to exude a most permeating odor. The nostrils are placed at the apex of the snout, and, in those forms which are aquatic, are provided with valves. The tongue is a tactile organ,

and, by a special opening between the plates of the front of the mouth, can be protruded while the jaws are closed; in the Hydrophidæ a special arrangement permits this without admitting the water. The sense of taste is probably wanting, as the reptile swallows its prey without mastication, though some forms crush it in the coils of the body. All ophidians are carnivorous.

The serpents are covered by an armature of scale-like folds of the skin, which are ordinarily imbricated, though in some forms they are merely juxtaposed. The armature of the lower surface of the body, in terrestrial forms, consists of a series of transversely elongated scales, known as abdominal scutes, and the head is in most cases protected by a regular arrangement of plates or shields. These shields, modified or otherwise, and their arrangement, are of great value in determining species, as they are very characteristic. The scales of the body are either smooth or provided with one or more longitudinal ridges, or carinæ, and are arranged in longitudinal rows of equal number each side of the vertebral ridge, along which there is generally a more or less peculiar series, though in *Stenostoma* and *Herpetodryas* this row is absent, making an even number of rows. In some forms, like *Naja*, which distend their necks, the number of rows in that region is increased. The ventral scutes are

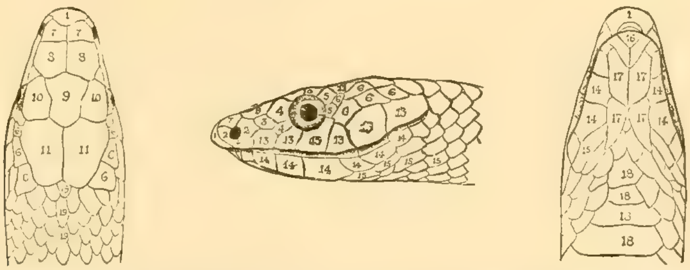


Fig. 207.—Upper, side, and lower views of head of snake, to show the plates covering it. 1, rostral; 2, nasal; 3, loreal; 4, preoculars or anteorbitals; 5, postoculars or postorbitals; 6, temporals; 7, internasals; 8, prefrontals; 9, frontal; 10, superciliary or supraocular; 11, parietals; 13, labials; 14, infralabials: 15, gular; 16, mentals; 17, sub-mentals; 18, ventrals; 19, dorsals.

ordinarily entire in outline, though in Dendrophidæ they have a pair of notches, and in Hydrophidæ they are replaced by scales of the ordinary kind. As each of these abdominal scutes is attached to a pair of ribs, their number corresponds with the number of vertebræ, and is hence of considerable diagnostic value. The scute immediately in front of the anus is often divided, as are those underlying the tail, the sub-caudals.

Of the plates of the head it may be said that, as they vary but little in different individuals of the same species, they are the most important factors in specific determination. They are named from the parts of the head which they protect. The frontal scute overlies the frontal bones, and is generally entire; posterior to it is the pair of parietals, while anterior are the prefrontals, or, as they are sometimes called, posterior nasals. Bordering on the parietals, frontal and prefrontals, and extending out over the eyes, are the supraorbitals or supraciliary plates, while posterior to the parietals are the generally scale-like occipitals. At the point of the snout is the rostral, and lying between it and the prefrontals are the internasals. The labials line the upper lip, and in the pythons are deeply pitted. The lower lip is similarly armed by the infralabials. In front, the rostral is opposed to the mental or chin plate. Around the eye are anteriorly the preorbitals, posteriorly the postorbitals, and, frequently, below the

infraorbitals; behind the postorbitals are the subdivided temporals. The nostril opens through a plate, the nasal, which may be and often is divided; between it and the preorbitals is the loreal, a shield quite characteristic of harmless snakes. Posterior to the mental, and lying between the infralabials, are the submentals and gulars.

Ordinarily the serpents have regular periods of sloughing the skin, which differ with different forms. Some little time before the change takes place, the waste skin so cleaves from the eyeballs as to render the serpent partially blind, making it unusually irritable. The skin then splits away from the margin of the mouth, and either by gliding through some narrow opening, or by passing through a ring of its own body, the serpent emerges, leaving its old coat turned inside out, but in perfect condition. If, as often happens in confinement, the animal has become ill, the sloughing is only partial, and, losing all appetite, it eventually dies.

As a rule, with the exception of a hiss produced by forcibly expelling the breath, the serpents are dumb; though Krefft maintains that some make a drumming noise, and the Indian *Ptyas mucosus* is said to give rise to a note like that of a tuning-fork. Garman has observed that some of the boas whine.

The progression of ophidians is reducible to three modes. The animal may glide, perhaps in a perfectly straight line, by use of its ventral scutes, each, on finding some resistance, forcibly pushing the animal forward. It may walk, by allowing each scute to act as a pair of feet, the lateral portions being alternately carried forward and pushed back; an undulatory movement like that of myriapods would result from this mode. The third manner is by pushing, as the underground snakes do almost exclusively. Ordinarily ophidians combine the three methods. The sea-snakes progress by an undulatory movement, and by the sculling action of the paddle-like tail. No serpent can move forward on a perfectly smooth surface.

It is impossible for any ophidian to jump, and it is with extreme difficulty that more than the anterior half of the body can be raised, unassisted, from the ground, though with some support, as the side of a box, the animal can stand almost vertically. In habits they are chiefly diurnal, though there are several tropical forms which hunt during the night. Most, if not all, have some period of the year during which they become inactive. In the torrid zone this may be called æstivation, while in the colder climates it is true hibernation, the animal being apparently in deep sleep; though if kept warm and constantly irritated it will pass the winter as it does the summer, and without any ill effects.

The coloration of ophidians is varied, and offers some of the most striking illustrations of adaptation and protective resemblance. Some of the rattle-snakes, which live in more wooded sections, are, on exposure on the hot neighboring plains, changed to a much lighter shade, and the members of all families have the general coloration harmonizing well with their surroundings. The tree-snakes are always of colors resembling either the leaves or twigs among which they live. The common grass-snake, *Cyclophis vernalis*, offers an excellent illustration of adaptive color. In the tropics many perfectly harmless forms have adopted the coloring of the most venomous, while the *Tropidonotus macrophthalmus* offers perhaps the most wonderful illustration of protective resemblance known to the order. This innocent animal has not only the general form, habits, and markings of the deadly cobra, but even that animal's distensible neck and elongated ribs,—a perfect counterfeit.

Whether snakes swallow their young has been much discussed. The case stands

thus: Many people maintain they have seen the animals pass into the mother's mouth in time of danger; some fishes, *Arii*, are known to protect their young by retaining them in the mouth; a male amphibian, *Rhinoderma darwinii*, carries the eggs in a laryngeal pouch until they are well developed; young serpents could live for some time shut up in the mouth, gullet, or even stomach of their parents; the belief is an old one and well established. On the other hand, no naturalist of good standing has ever been able to observe the young serpents thus seek safety; and of the serpents found in the gullet of dissected snakes, all have been of a different species, or immature individuals of the same species as their devourers, and were undoubtedly taken as food.

The skeleton of ophidians is chiefly axial, there never being any pectoral girdle, and only rarely (in Opoterodonta and a few families of Colubriformia, as the Tortricidæ, Pythonidæ, and Boidæ) a pelvic girdle with rudimentary limbs. When the hind limbs are present, they appear, externally, as two short claws or processes each side of the anus, and are probably used as clasping organs. The two rami of the lower jaw are not united in front by a bony symphysis, but by an elastic ligament, giving them considerable lateral expansion with the ordinary vertical movement. The bones of the upper jaw are also so connected with the other bones of the face as to allow more or less individual movement. The teeth are never permanent, but are capable of being renewed, like those of fishes, as soon as the old ones are worthless. They all point backward, and those of the palatine and pterygoid bones resemble the armature of the jaws.

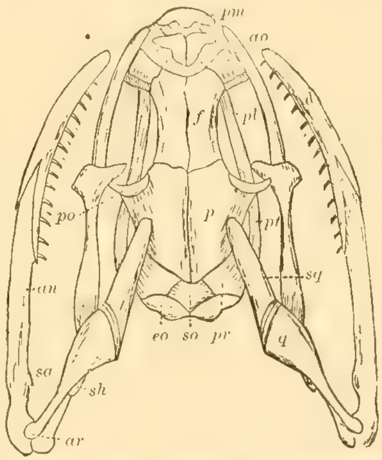


FIG. 208.—Skull of snake (*Tropidonotus*); *an*, angular; *ao*, antorbital; *ar*, articular; *d*, dentary; *eo*, exoccipital; *f*, frontal; *p*, parietal; *pl*, palatine; *pm*, premaxillary; *pr*, prootic; *pt*, pterygoid; *q*, quadrate; *sa*, surangular; *sh*, stylohyoid; *so*, supraoccipital; *sq*, squamosal.

The vertebræ are concave in front and convex behind, and connected by free ball and socket joints, twisting being prevented by horizontal articular surfaces; those of the body seldom exceed three hundred in number. The ribs are the chief organs of locomotion, being attached at their free ends not to a sternum but to the ventral scutes.

The alimentary system is elongate and adapted to the general form of the body. In the distensible mouth the food is subjected to the treatment of saliva, which, in its ordinary form or as poison, is given off in considerable quantities, and materially aids in the process of digestion. The stomach is a simple enlargement at the end of the œsophagus, provided with longitudinal folds, and in turn leads into a relatively short intestine. The liver is asymmetrical, and passes from the anteriorly placed heart to the pylorus; its reservoir, the gall bladder, is somewhat removed, and is placed, with the pancreas and spleen, in a fold of the duodenum. Though serpents drink a great deal of water, and will perish if it is not given them, they have been kept for months without nourishment of any kind whatever.

The respiratory system is peculiarly specialized. The lungs are paired only in the boas, some Proterogylphs, and the Crotalidæ, in other forms only one is developed, which may be specialized into an air-sac posteriorly, its fellow appearing only as a rudiment. The trachea is long and may be provided with air-cells, and the larynx can be projected

during the tedious process of swallowing, when, too, the tracheal air sacs and the posterior reservoir come into play.

The ovaries and testes are paired; the right, however, is often the larger and placed in advance of the left. The male has a pair of intromittent organs, which are grooved, and, when in use, are everted, like the finger of a glove. Some species have these organs armed with sharp spines or hooks, anticipating the special development of some of the rodents. No urinary bladder is found in Ophidia.

The eggs of serpents are oblong in form and covered by a leathery envelope, for the rupture of which the embryos are provided with an egg-tooth, a special development like that of the chick. The eggs, whose embryos are well advanced before deposition, are ordinarily left to care for themselves, though the pythons continue to protect them, winding their body around, and, with their feeble heat, incubating them. In some forms, especially the members of the Solenoglypha and some of the Proteroglyphs, the eggs hatch in the oviduct, an occurrence which may happen in snakes ordinarily oviparous, and the young are thus *born*. The classification herein adopted arranges all the members of the order Ophidia in four sub-orders: Opoterodonta, with non-distensible mouth, facial bones immovably connected, teeth only in one of the jaws, and the posterior limbs as rudiments; Colubriformia, having teeth in both jaws, no fangs, and including all the more common harmless snakes; Proteroglypha, poisonous snakes, with large, permanently erect, grooved fangs, which are placed anteriorly in the upper jaw, and are usually immediately followed by ordinary teeth; Solenoglypha, with the perforated fangs unaccompanied with ordinary teeth and capable of being depressed.

Sub-Order I. — OPOTERODONTA.

The first sub-order includes those forms which, because of their imperfect eyesight (rendered so by the odd arrangement of the lateral cervical plates, which so cover the eye as to render vision extremely indistinct), are popularly known as 'blind-worms.' They are provided with a narrow, non-distensible mouth, and the bones of the head are more firmly united together than those of other ophidians. The solid, hooked teeth are only in one jaw (upper or lower) and the body is terminated by a short tail. Posterior limbs are sometimes present as rudiments. The larger number of species belong to the genus *Typhlops*.

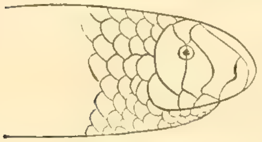


Fig. 209.—Head of *Typhlops*.

The Typhlopidæ are very generally distributed over the warmer portions of the globe, four species being found in our country north of Panama. To the naturalist they are most interesting forms and are eagerly sought after. They are the lowest as well as the smallest ophidians, — an ordinary earth-worm is gigantic when compared with some. Their short muscular body, designed for underground tunnelling, rudimentary eyes, and peculiar dentition, are special points of interest. The genus *Typhlops* has the body covered with small imbricate scales; the tongue forked; a pair of scarcely discernible eyes; and the lungs unequal in size. The head may be obtuse, depressed, or in some species drawn out into a horny tip; the tail may also be ensheathed in horn, as is the case with *Typhlops philippinus*. The upper jaw is toothed. Many species of this genus inhabit British India, where, after showers, they come above ground and are very active.

Of the four American species, *T. longissimus* is a doubtful form, which has not been met with since the time of its description by Dumerel and Bibron. *T. perditus* and *T. basimaculatus* are Mexican forms in which the eyes are invisible. The general color of the latter is yellow, but the more dorsal scales are minutely spotted at their bases, while the head and tail are immaculate. *T. emunctus* is very long and slender, though the tail is not longer than the diameter of the body. The color is silvery brown, the snout and lips light yellow. It is found from Panama northward.

Australia has nearly a dozen species of this genus, most of which have been named after men who have distinguished themselves as herpetologists. They are all underground forms, chiefly feeding on ants and their eggs. In burrowing they are greatly facilitated by the general form of their body, which is of a larger diameter posteriorly and is terminated by a short acuminate tail.

A second genus, *Anomalepsis*, characterized by having the crown shields regularly arranged, is found in Mexico. *A. mexicanus* is long and slender, with tail like Typhlops, and eyes visible through the semi-transparent ocular shield. The labials are only two in number, though the previous genus is provided with four. The color is reddish-brown, of a lighter shade below; the yellowish-white border of the individual scales gives the animal the appearance of being reticulated. The genus *Stenostoma* is provided with teeth in the lower jaw, and the shields of the crown are reduced to scales. The ocular is large and transparent, displaying the eye beneath. Members of this genus are quite abundant in Mexico, a form having the scales arranged in fourteen longitudinal rows, the two labials separated by the ocular, and the infra-labials four, inhabits Texas, and is known as *S. dulce*. Allied to this is *S. rubellum*, which has five infralabials and reaches a length of eight inches.

Sub-Order II. — Colubriformia.

This group embraces all the harmless ophidians except the forms already treated under the head of Opoterodonta. As a general rule these serpents have the maxillary and mandibulary, as well as the palatine and pterygoid bones, well provided with small recurved teeth, and in some forms those of the mandible, posteriorly, may become fang-like and conduct poison from a venom gland. Such forms are, however, rare, and, though evidently poisonous, are not regarded as being dangerous. The several members present a great variety of form, and can more easily be distinguished from other sub-orders than they can be comprehensively defined as members of a single group circumscribed by distinctive characters. The colubriform snakes are found in the temperate regions, usually as terrestrial forms, while in the tropics they are not only found on the ground, but many are arboreal. Aquatic forms are abundant in some localities. Not only are colubriform snakes beneficial in destroying vermin, such as mice and rats in the southern states, and the troublesome pouched-gophers, *Geomys bursarius*, in the West, but some of these innocuous forms do not hesitate to battle with the most poisonous Solenoglyphs, which they often defeat.

As before said, though the majority of colubriform snakes are harmless, and are only too glad to retreat from the sight of a human being, a few are aggressive. Some of the tree-snakes, Dendrophidæ, do not hesitate to spitefully attack travelers as they pass unsuspectingly through the jungles, and often — as they choose the eye as the point of attack — inflict dangerous wounds. The pythons have been known to attack

and kill full-grown men by their powerful coils, though those reptiles are ordinarily of a most timid nature, retreating on the least disturbance. The variations in form presented by the sub-order have their extremes in the short thick body of the Tortricidæ, or the bluntly terminated body of *Silybura*, and the slender elongated form presented by many of the Dendrophidæ. A few, such as the pythons and boas, and some of the Erycidæ, as well as the Tortricidæ, have the pelvic limbs represented by a pair of anal claws.

The first to be treated, and, consequently, the lowest family of colubriform snakes, includes a number of Asiatic underground forms, having many characters in common with the Typhlopidæ, united under the name Uropeltidæ, or shield-tails. The members of this family have the cylindrical body passing without any visible constriction into the short pointed head. The tail is abbreviated and often terminates abruptly in a naked disc, or, in the genus *Silybura*, covered with keeled scales. The eyes are very small, and the cleft of the mouth of inconsiderable width, and not distensible; the jaws are armed with but a small number of teeth. The shield-tails, it will thus be seen, are adapted for an underground life, where they find larvæ, worms, and ants' eggs, of which latter they are very fond. Though seldom met with, they are very abundant in numbers, and chiefly inhabit the island of Ceylon, though some forms are found on the neighboring mainland. The genus *Rhinophis* includes several Cinghalese species, characterized by having the nasal plates separated by the rostral; and the tail, which is shorter in the female, covered by smooth scales, and terminated by a rough shield. *R. oxyrhynchus* reaches a length of fifteen inches, and is found in the loam at a depth of two or three feet, as well as in ant-hills. *R. punctatus*, which attains the length of nineteen inches, is the largest species.

Of the genus *Uropeltis*, only a single species, *U. grandis*, the largest of the family, is known. It inhabits the mountains of Ceylon and is extremely rare. The genus *Silybura* includes a number of species which have the scales of the abrupt tail strongly keeled, and the supra-orbital and postocular shields confluent. *S. macrolepis* is represented by a single Indian specimen measuring ten inches in length. *Plecturus* has only two uninteresting forms. The final genus of the Uropeltidæ contains but a single species, *Melanophidium wynaadense*, which has the termination of the tail armed with a rough horny point. The genus and species have been described from a specimen captured at Wynaad at an elevation of 3,500 feet.

The second family, Tortricidæ, or short-tails, have the short, blunt head depressed, and not distinctly marked off from the body, which is protected by evenly laid, smooth plates, those of the ventral side exceeding the others but little in size. The eyes are small; the labials but six in number; and the teeth are few but stout. The most noteworthy feature, however, is the rudimentary pelvis, which bears a pair of small limbs which make their appearance each side of the base of the tail as small claws. Members of this family are found in both hemispheres, where they prefer the dry and sandy districts, burrowing near the surface for subterranean worms and insects. *Tortrix scytale* is beautifully banded with black, and does not exceed two feet in length. Its habitat is the valley of the Amazon, the natives often wearing it as an animated neck-ornament. *T. eryx* inhabits southern Europe and Egypt. The genus *Cylindrophis* is characterized by the absence of intermaxillary teeth. But three species are known, two of which inhabit British India, where, being, like the other members of the family, sub-terrestrial, they are seldom found.

To the family Tortricidæ may be appended the genus *Xenopeltis*, to which some

naturalists give a family value. *Xenopeltis* has eight labial plates, and the ventral scales well developed; it is represented by a single species, *X. unicolor*, which inhabits Borneo, Sumatra, Java, the Celebes, and other neighboring islands, as well as a portion of British India. In its habits it is nocturnal, and obtains its prey of small mammals by entering their burrows. Being a large and stout animal, sometimes reaching the length of four feet, it has little difficulty in overpowering its victims.

The third family embraces the ERYCIDÆ, or sand-snakes. Members of this group have a small conical prominence on each side of the vent, somewhat resembling the anal spurs of the Boidæ; the tail, however, is much shortened, and, instead of being

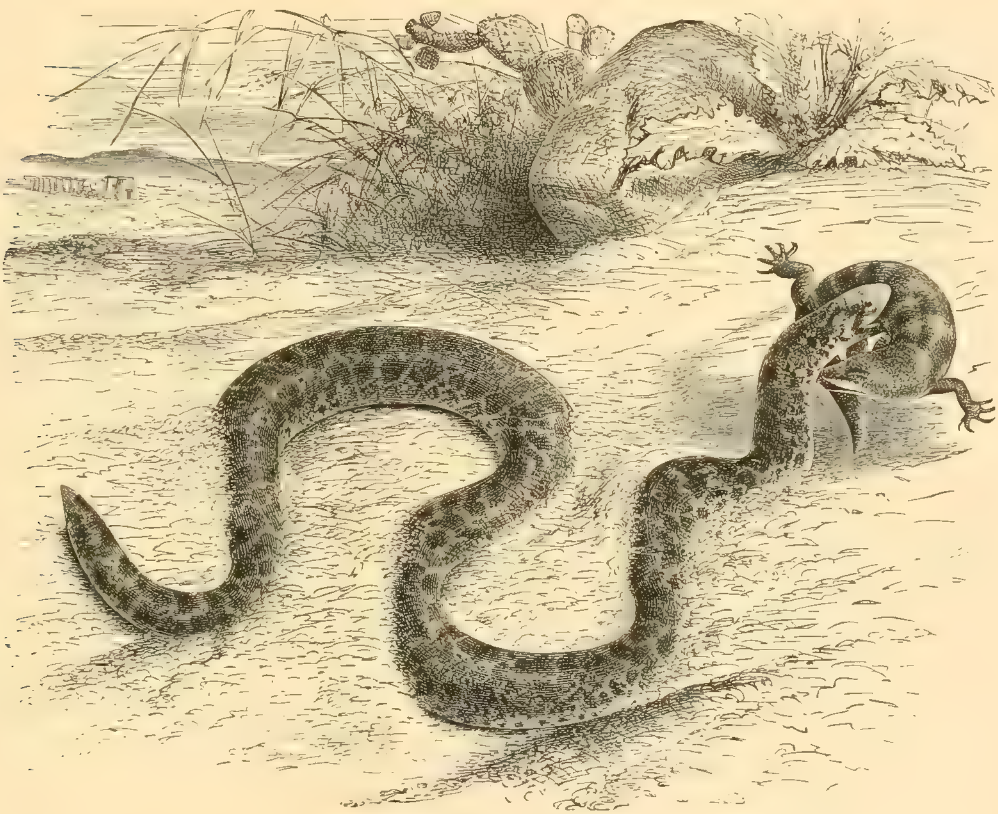


FIG. 210. — *Eryx jaculus*, sand-snake.

used as a prehensile organ, is so developed as to act as a lever, assisting the animal in working its way into the coarse gravel of the barren plains which it inhabits. Nearly every desert has its representatives of these most interesting reptiles: America has *Charina plumbea*. *Eryx jaculus* is restricted to southern Europe and Persia, while in India is found the harmless *Eryx johnii*, which the serpent-charmers so mutilate about the short, rounded tail, as to give the animal the appearance of having a posterior head, —a monster regarded with the utmost horror by the ignorant natives. In confinement this Indian form constantly remains hid in the gravel of its cage, from which it cannot be induced to appear, except by offering it the most tempting morsels. In its native haunts, the treeless deserts, the animal is probably crepuscular, as its food — mice

and small reptiles — is much more abundant at evening, or during the early morning, than under the enormous heat of a nearly vertical sun.

We now come to those ophidians, PYTHONIDÆ, which, because of their great size, have been known from the time of the earliest writers. Though of dimensions large enough to satisfy the cravings of the ordinary searcher after the marvellous, they have nevertheless been the subject for most exaggerated stories, and it is extremely difficult to find data which have not been more or less subject to the influence of imagination. The ancient writers were especially fond of magnifying the powers of these serpents. Valerius Maximus writes: "And since we are on the subject of uncommon phenomena, we may here mention the serpent so eloquently and accurately recorded by Livy; who says, that near the river Bagrada, in Africa, a snake was seen of so enormous a magnitude as to prevent the army of Attilius Regulus from the use of the river; and after snatching up several soldiers with its enormous mouth, and devouring them, and killing several more by striking and squeezing them with the spires of its tail, was at length destroyed by assailing it with all the force of military engines and showers of stones, after it had withstood the attack of their spears and darts: that it was regarded by the whole army as a more formidable enemy than even Carthage itself; and that the whole adjacent region being tainted with the pestilential effluvia proceeding from its remains, and the waters with its blood, the Roman army was obliged to remove its station: he also adds, that the skin of the monster, measuring 120 feet in length, was sent to Rome as a trophy." Krefft, alluding to this piece of remarkable history, says; "Snakes 10 to 14 feet long are considered very large nowa-days, and in former ages may have kept armies at bay, but our better acquaintance with their habits enables us to treat them with the contempt they deserve."

Not only has the size of these animals been exaggerated, but their swallowing powers have, in some works, appeared as almost unlimited. The animals on which the pythons ordinarily feed are seldom larger than a small dog, and though they may seize and overpower animals as large as a goat, to swallow them "horns and all" is absolutely impossible.

The Pythonidæ, in general structure as well as in their habits, resemble the Boæidæ, though they are all Old World forms, and have some of the labials deeply pitted, a characteristic which at once determines them. There are skeletal characters also which can be made use of in identification. In the boas the frontal bones are broader than long, while the opposite holds for the pythons. The rock-snakes, or Pythonidæ, inhabit tropical Asia, Africa, and Australia, and though accounts are not rare of their attaining the fabulous length of forty feet, specimens by actual measurement very rarely reach one half that length. The body is rounded; tail prehensile; head depressed and rounded in front; eyes of moderate size, the elliptical pupil having its longer diameter vertical; scales smooth, subcaudals in two rows; some of the labials are pitted; teeth on the intermaxillary, maxillary, palatine, pterygoid and mandibulary bones and none grooved; and the adults are provided with rudimentary hind limbs, placed each side of the vent, and called 'spurs.' These organs are supposed by the natives to be used in fighting, though they probably have sexual functions, or may be of use in grasping the limbs of trees as the animal swings over the surface of the water. Pythons generally prefer those localities which border on some quiet pool, where they lie in wait, either suspended from an overhanging limb, or hid in the luxurious vegetation of the ground, or possibly partly submerged in the water, waiting the arrival of some small animal, which, as it is about to drink, the reptile seizes by the snout,

and, after wrapping several coils of its body about it, strangles. Finally, having crushed the larger bones, the process of deglutition is begun, which may last for several hours; the head invariably being the first to pass into the gullet, the body following. As the teeth all point inwards, and the jaws are successively and alternately pushed forward and drawn back, the prey, if not too large, is thus of necessity drawn into the mouth. The reptile may, however, find that its food is not suitable, or it may need to take breath, and though the prey has passed some way down the œsophagus, it is not unfrequently disgorged, making its appearance as a most frightfully contorted mass, covered with mucus from the alimentary tract; its slimy appearance having undoubtedly given rise to the false notion that the animal covers its prey, previous to deglutition, with saliva. For some time after the reptile has taken a large meal, it is, either from fatigue or from the effects of so loading its stomach, extremely lazy and inactive, being not infrequently quite indifferent to what may be going on about it. The inactivity of menagerie specimens, however, is due rather to the enfeebling effect of a cold climate, rather than torpor resulting from overfeeding, or gentleness from kind treatment. It is in their native forests that these forms must be studied to be admired. Not only are the caged animals inactive, but the purple bloom, so characteristic of the healthy animal, is invariably defective or lost; the rough treatment to which they are subjected, as well as a disease of the jaw, — caries, — rendering them indifferent and unhealthy.

It is not an unusual occurrence for the female python, which exceeds the male in size, to deposit her eggs while in confinement and watch over them with the most zealous care. Observations have been made which prove that the eggs are actually incubated. The mother, after arranging them in a convenient pile, coils her body, the temperature of which is considerably above the normal, around and over them, remaining in this position until the eggs, at the end of about three months, are hatched. We have here among the reptiles an undoubted instance of maternal solicitude.

Python reticulatus has the following characteristic marking. The underlying color is light yellowish-brown or olive, and the head and neck is ornamented by a dark brown line passing from the tip of the snout backwards, on each side of which are two bands passing from the eyes to the angles of the mouth. Along the back a series of black rings bordered with white, spotted scales gives the animal a netted appearance, from which it has received its specific name, *reticulatus*. The netted python is found quite abundantly in nearly all the islands of the Malay Archipelago, as well as in Burmah and Siam, where it is called Ular Sawad.

Mr. Wallace, in his description of these islands, gives an account of a python which illustrates the bold and independent yet helpless nature of this, or a closely allied, mammoth serpent. It seems that during the evening, while the naturalist was interesting himself with his books and insects, a python took up its abode in the thatched roof directly over the bed, not making its presence known, however, until the following afternoon, when it was finally disposed of by a native well accustomed to its habits, though it evinced all the indignation of a regular tenant.

Python molurus, the adjiger of the Hindus, inhabits the peninsula of India as far north as the Himmalehs and also possibly the Malay peninsula and Java. Like other members of the family, it prefers the low moist lands in the neighborhood of water, where it captures birds and small quadrupeds, such as fawns and rodents. It differs from the previous species in several particulars. *P. molurus* has the two anterior upper labials, and four of the lower labials, deeply dented with pits, while *P. reticu-*

latus has four upper and *several* lower labials similarly developed. *P. molurus* has its light, greyish-brown body ornamented with a dorsal row of large square spots, below which are two lateral rows. The top of the head is ornamented with a lance-shaped blotch, along each side of which lie a pair of dark brown lines, which pass from the nostrils, through the eye, to the sides of the head, where each meets a similar streak from the lower jaw.

Python regia, the royal rock-snake, having the four anterior upper labials pitted,

FIG. 211. — *Python sebæ*, fetich-snake.

and the lower labials broad and four in number, inhabits western Africa. It is of a dark brown color, almost black, and has a series of light spots along the middle of the back, and two more along the sides, beneath, the lips and chin are white. This python is quite often seen in menageries and traveling shows. *P. natalensis*, the Natal rock-snake, is regarded with respect by the natives, believing that it has some mystic influence over their destinies. It lives on small quadrupeds, remaining quite torpid for some time after its meal. At this time it is quite easily disposed of. *P. sebæ* is a

form often met with in zoological gardens, where it is known as the fetich-snake. Its home is in the warmer parts of Africa.

In Australia there are at least six species of Pythonidæ and more genera than of any other innocuous family. The representatives are the largest ophidian inhabitants, some reaching the length of ten feet. They are nocturnal and move during the day only when compelled to. The genus *Morelia* has the rostral plate, as well as the anterior three labials and the posterior infralabials, provided with deep pits. *M. spilotes* is of a glossy black color, with a bright yellow spot on every scale; the abdominal scutes are yellow, with shades of black. This animal may be distinguished, as can the other Australian rock-snakes, from the numerous poisonous forms inhabiting the same country, by the large number of scale rows, there being from forty to fifty in the pythons, while the largest number known among the poisonous snakes is twenty-six. It is a strange coincidence that while the so-called 'diamond snake' of Australia, the form now under consideration, is harmless, the *Hoplocephalus superbus*, inhabiting the neighboring island of Tasmania, and bearing the same vernacular name, is highly venomous. *M. spilotes* has a very limited distribution in southeastern Australia, being only found from the coast to the Blue Mountains, but is represented further west by the following species. The individuals of this species inhabit nearly every region that offers shelter, though stony ridges supplied with trees and well watered seem to be their favorite localities. It is in such places that they can find young water-rats, (*Hydromys*) ducks, and possibly the straying chickens of a neighboring farmer. Though naturally unobtrusive, when irritated they bite severely. The eggs of either this or the following species have been found. They were neatly piled up in a nest of dry grass, which was concealed in a hollow log. *M. variegata*, or the carpet-snake, closely resembles the diamond in its habits and structure, though its habitat is defined and separate. It is found in every other part of the continent except southern Victoria, the region of the diamond snake. In coloring it is of a uniform greenish brown with irregular markings; different specimens show a great variation due to age and locality. In their movements and general habits the carpet and diamond snakes are similar, though the former may be somewhat the larger.

The genus *Aspidiotes* has the scales in fifty-two rows and reaches a length of eight feet, and may possibly grow larger, even exceeding the *Morelias* in size. The species are not well known, and only a few specimens have been captured. *A. melanocephalus* is at once recognized by its jet-black head and neck, its small scales, narrow abdominal plates, and the absence of pits in the labials. The general color is light brown, with darker rings above, and yellowish white below. Allied to this genus is *Liasis*, the representatives of which have some of the upper and lower labials pitted. The few species are found in the islands of the Arafura sea. *Nardoa* has only the posterior infralabial pitted. *N. gilbertii* has a length of from three to six feet. Of its habits little is known.

Of the family of boas, the Boidæ, it may be said that its members are distinctively New World, resembling the pythons in their habits, and in being of enormous size, but differing from them in several structural particulars. The boas have the body long and fusiform; the head distinct and flattened; the snout prominent; the tail generally prehensile; the nasal plates may be entire or divided; the nostrils lateral. The labials are generally without the pits so characteristic of the Old World forms, many of the cephalic shields are divided, and the sub-caudals are entire.

Boa imperator, or the emperor, is found in Central America and Mexico, and may

possibly be regarded as a northern variety of the more tropical *Boa constrictor*, though the scales of the head are rather large. The general color is brownish, with a dorsal series of quadrangular brown spots, which is separated from the smaller spots of the flanks by a pair of light lateral lines. *B. constrictor*, though properly an inhabitant of Brazil, is represented in Central America by a variety, *isthmica*. Along the back is a series of transverse brown bands, each connected with the marks of the flanks by a latero-posterior isthmus, and along each side of the belly is a series of more

FIG. 212. — *Boa constrictor.*

or less broken, irregular spots of a black color. *B. mexicana* is allied to *B. imperator*. *B. constrictor*, proper, inhabits the more tropical portions of South America, though travelers from all parts of the world have almost invariably described large serpents which have come under their notice as 'Boa-constrictors,' rendering it extremely difficult to determine acurately what species they are describing, and bringing the name to so general a use that it has almost lost the primary significance given it by its original propounder, Linné.

Eunectes murinus, the anaconda, is also a native of tropical America, and is represented in the engraving as in its native haunt, the low land by some pool or sluggish stream, about to seize a 'boat-bill.' The anaconda is one of the largest representatives of the family, and is beautifully ornamented over a groundwork of rich brown, by a double series of blotches along the back, and with irregular annular spots along the sides.

FIG. 213. — *Xiphosoma caninum*, dog-headed boa.

Xiphosoma caninum, or the dog-headed boa, inhabits Brazil, and is of a green color with light dorsal bands. The labial plates resemble those of the pythons in being deeply pitted.

Epicrates cenchria, the ringed boa or aboma, was at one time worshipped as a god by the ancient Mexicans, who often offered to it human sacrifices. In its habits it is a true member of the family, strangling its prey by winding around it fold on fold of its ponderous body. Its general color is of a dark yellowish gray, ornamented with a dorsal row of large brown rings, and along the sides by variable blotches of a dark color, having in their centre a lighter crescentric ornament.

A large number of the smaller serpents are united under the name CALAMARIDÆ, or dwarf-snakes. The members of this group are found in nearly every country of the globe, living beneath stones and prostrate logs. Their diminutive size and nondistensible neck compels them to restrict their diet to such small grubs and worms as they can easily master and swallow; while they are thus employing themselves they not infrequently become the prey of some larger foraging reptile. The genus *Calamaria* which is only found in the East Indies, has the labial plates reduced to four or five. Though there are several species, they resemble each other so closely that they can be classified only after considerable trouble. The *Elapes* are their particular enemies. The genus *Geophis* is represented in America by four species, all of which inhabit Mexico, where are also found the genera *Ficimia*, *Cheilorhina*, *Stenorhina* and *Tantilla*. *Virginia striatula* is a little snake found in the south, from Virginia to Texas.

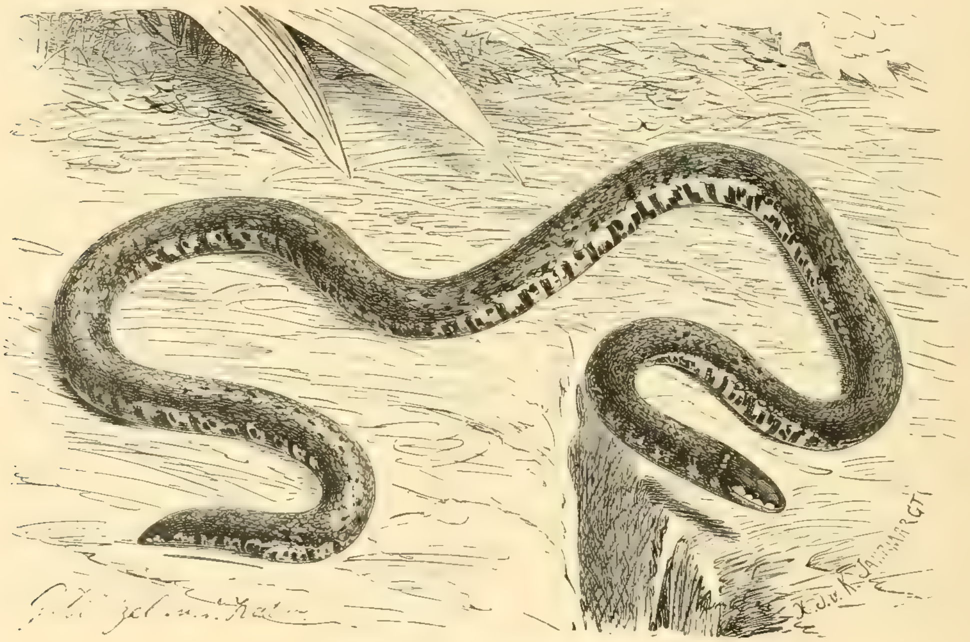


FIG. 214. — *Calamaria albiventer.*

It is a modest and most inoffensive reptile; its reddish-brown back and salmon-colored inferior surface form a combination far too pleasing to be hid away, as it too often is, beneath the bark of some old dead tree or log.

The genus *Carphophis* is very generally distributed; in the United States, the species *amœna*, inhabiting the more eastern and northern portions, as the thunder, ground, or worm-snake, is most familiar. In its habits it is nocturnal and sub-terrestrial, being much more often turned up by the plough, or brought to light by the hoe, than seen naturally on the surface. It, moreover, always seeks escape by burrowing, rather than by flight; indeed, the animal's motions, when out of its element, are most awkward. In general coloration it resembles the previous species. The East Indian *Oligodorus* belong to this family, and are characterized by the absence of palatine teeth, and by their peculiar physiognomy, the head being short and blunt. Closely resembling the *Oligodorus*, externally, are the members of the genus *Simotes*, which,

Eunectes murinus, anaconda.

however, have an armature of palatine teeth, and reach a considerable size. They are known in southern Asia, as well as on the neighboring islands, from their fierce habits.

We now come to a large family of cosmopolitan ophidians, the Coronellidæ, found in nearly every country, though rare in Australia. They have the body tapering towards each end; the head, which is separated from the body by a distinctly constricted neck, depressed, short, and often obtuse; the scales of the body are usually smooth, and arranged in from thirteen to twenty-three rows, and in size the magnitude of many members of the genus *Coluber* is not reached. Though generally inactive, on being attacked they defend themselves with considerable energy. In coloration, being mostly terrestrial forms, they are generally dull, though some which

Fig. 215. — *Ophibolus getulus*, chain-snake,

inhabit grass land, are bright-colored, and are among the most graceful, as well as most beautiful, of ophidians.

The genus *Coronella* includes a number of purely terrestrial forms, inhabiting nearly every temperate and tropical country. *Coronella austriaca* is very generally distributed throughout Europe, where it is often mistaken for the viper. It has, on rare occasions, been found in England. *C. cana* inhabits south Africa. *C. orientalis* is described as the only representative of the genus in India, and the *C. australis*, or the Australian ground-snake, has been described from a single specimen in the British Museum. As considerable work has been done on the Australian snakes by native naturalists, and as no second specimen has been discovered, the form must be extremely rare. It not only represents the genus, but the family, in the insular continent.

In North America, the family under consideration is represented by several

common serpents belonging to the genera *Ophibolus*, *Diadophis* and *Heterodon*. *Ophibolus triangulus*, the milk-snake, is found from Canada to Virginia, and has received, from its habit of frequenting old cellars and out-houses, while in search of mice and small vermin, snakes and lizards, the name of house-snake; its confidence has been taken advantage of, however, and it has, of late, become quite uncommon. It is a most beautiful, graceful, and active animal, and the slender body sometimes reaches a length of four feet. The chain-snake, *Ophibolus getulus*, is a more southern animal. In the south it is one of the most beautiful, as it is one of the most common, snakes. Its body is of an intense black, ornamented by a series of narrow, white rings, from the arrangement of which the animal has received its common name. The negroes hold this serpent in the highest respect, and even give to it the name of 'king.' They maintain that it exercises dominion over the other reptiles, and can meet and overcome the deadly rattler. The diet of the chain-snake is ordinarily made up of lizards, salamanders, small birds, and mice, as well as weaker members of its own species.

Diadophis punctatus, or, as it is more popularly called, the ring or collared-snake, is one of the most beautiful reptiles of our continent, over which it is very generally distributed, east of the great plains. In its choice of raiment *Diadophis* has shown most excellent taste, and, at the same time, good judgment. Above, a dark sage-green, given the appearance of Highland plaid by the regularly arranged scales, harmonizes with the shades of vegetation in which the little fellow searches for his luncheon of bright-colored beetles and grasshoppers. He seems to know that below he can wear a little bright color, which, being hid from above, will not attract the attention of his enemies; so he has decked himself in an orange waistcoat, sometimes ornamented with a double row of black buttons, and finally finished his dandy costume by putting on a white collar and black cravat. From its gaudy attire the ring-snake is often selected as a pet, and soon becomes accustomed to its new surroundings.

Having a distribution very nearly coincident with *Diadophis punctatus*, though a much less interesting animal in appearance, is the puffing-adder, hog-nosed snake, or sand-viper, *Heterodon platyrhinos*. This serpent is large and unsightly. The rostral plate is so formed as to resemble the up-turned snout of the hog, and when surprised, if retreat is impossible, it flattens itself out, appearing to be twice its ordinary size. It delights in dry, sandy districts, where it sometimes remains perfectly motionless, basking in the sun for hours at a time; or it may partly bury itself in the loose sand, using its peculiar snout as a spade. From its uncouth appearance this reptile is generally considered to be extremely poisonous. It is strange that such a character should be given to a form which is perfectly harmless, and can be induced to *feign* the aggressive only after protracted ill-treatment. I have repeatedly placed my finger in the mouth of one that seemed to be of the most ferocious disposition, but no attempt was made to bite. Of a half dozen North American *Heterodons*, the one under consideration, which inhabits the United States, east of the Mississippi, is most familiar, though it is in part replaced, in the south, by a black variety. The females are very prolific, as many as one hundred and eleven being born of a specimen in the National Museum. *Heterodon* is also found in Madagascar, and in Chili, both being beautiful examples of the genus. Allied is *Psammophylax rhombeatus*, which is abundant in South Africa, where it is known as the schaap-sticker. It is a very graceful and active animal, about two feet in length, and feeds on small lizards and insects. Considerable variety of coloring is shown by specimens of unlike ages and from different localities.

In the family COLUBRIDÆ have been placed the greater number of non-venomous ophidians which do not present any striking characters either as to their habits or structure; a description must therefore be general. Body of moderate length and breadth; head well-proportioned and separated from the body by a more or less constricted neck; eyes and mouth of moderate size; teeth covering both jaws and palate, and never presenting any special development; the plates of the head are evenly arranged, and those of the body never present any outline or structure deviating greatly from the normal. So few prominent structural variations are presented by the several forms, that grouping from this standpoint is difficult and, at best, unsatisfactory. Some naturalists have endeavored to base an arrangement on habits. Yet, as many forms are intermediate, and others unite the habits of evidently widely separated groups, this plan is even more unsatisfactory than the first. The family is cosmopolitan, its members being found in nearly every country under the tropical and temperate sun. Australia and some of the Pacific islands, however, are not represented. North America has a large number of forms, included in several genera, the distinctive features of which are chiefly based on the arrangement of the cervical plates.

The introductory genus is *Cyclophis*, which is represented by one of the most beautiful, as it is one of the most familiar, reptiles, the green-snake, *Cyclophis vernalis*. This is a most gentle and harmless ophidian, allowing itself to be handled in the roughest way, and seldom offering the least opposition. Specimens are often captured and made pets of, living in confinement for considerable periods of time. In nature they are found in moist meadow-lands, where they are concealed by their protective color, and where they find an abundance of insect life well suited for their food. The green-snake is not only found on the ground, however, but is an active climber, and may not infrequently be seen entwined among the branches of bushes or of low trees. The genus is represented in India by a much larger form, *C. major*, which sometimes exceeds three feet in length.

Closely related to *Cyclophis* is the genus *Herpetodryas*, representatives of which are found in both hemispheres. They are elongated forms, adapted to an arboreal life, their colors, shades of green and brown, being well adapted to conceal them. *H. carinatus* is found in Brazil and Surinam, and is peculiar in that it has no vertebral row of scales, the several series of the body always being in an even number.

The genus *Coluber* has many interesting forms, native as well as exotic. The Alleghanian variety of *C. obsoletus*, the mountain black-snake, has received considerable attention, from its distribution. It was first detected in New England, along the Connecticut valley, where it attracted attention as a black-snake having the scales keeled, the ordinary *Bascanium constrictor* having the scales smooth, and though since found in other eastern localities, its proper home is among the mountains of the Appalachian range, where it sometimes reaches a length of seven feet. In confinement its temperament is quite different from that of its smooth-scaled cousin, being mild and gentle. *C. guttatus*, the corn-snake, inhabits the southeastern part of the United States, and was first described, in 1743, by Catesby, as follows: "It is all over beautifully marked with red and white, which seems to have given it the name of corn-snake, there being some maize or Indian corn much resembling this in color; they are robbers of hen-roosts, otherwise they are harmless." In its habits the present form differs from the majority of our common snakes in being crepuscular, spending the day hid away in some crevice. In length the corn-snake sometimes reaches five feet. This form has been a great stumbling block to herpetologists, having been described under a dozen different

names. *C. vulpinus*, the fox-snake, has been captured in Massachusetts, though its home is further west. *C. quadrivittatus*, or chicken-snake, as it has been called by the negroes, frequently enters the southern cabins for rats and young fowl. The body is of a dark olive color, ornamented with four longitudinal brown bands. Of exotic *Colubers*, *C. coreas*, of Surinam, is the largest, and *C. quater-radiatus*, the largest of Europe. The Æsculapian-snake, *C. æsculapii*, is the most common European type. Often they are seen in museums and menageries, where they become very tame. This form was introduced into the mythology of the ancients, who twined it around the staff of Æsculapius and the caduceus of Mercury, which, when thus equipped, were supposed to be possessed of the most wonderful virtues.

The genus *Bascanium* is represented in North America by five species, and twice as many varieties. The most characteristic, as well as the most familiar form, and the common black-snake, *B. constrictor*, inhabiting the United States east of the Rocky Mountains, and its variety, *vetustum*, west to the Pacific, while *mentovarius* extends further south, through Mexico to Tehuantepec. The common black-snake is most often found in the neighborhood of water, and is particularly partial to thickets of alders, where it can hunt for toads, mice, and birds, and, being an excellent climber, it is often seen among the branches of small trees and bushes, hunting for young birds in the nest. While on these plundering expeditions the reptile is often followed by a troop of small birds in the greatest flutter of excitement. The black-snake does not always remain in unfrequented localities, however, but is often surprised in old fields, by the roadside, and will even enter barns and seize chickens. At these times, the rapidity with which it retreats, on being surprised, has given the animal, in some localities, the name of 'racer.' As long as retreat is offered there is no resistance, though if cornered, or during the breeding season, the usual mild temper gives place to a most irascible disposition; this is very characteristic of the animal when in confinement, as it is always quarrelling and biting its fellow-prisoners, as often as the opportunity presents itself. The racer has been known to follow people, though this is more generally from a spirit of investigation, rather than from any design on the part of the animal to attack the object of its pursuit. Dr. Yarrow, however, knows of an instance in which a female, with its young, on being surprised by a small girl, entwined itself around the child's neck, biting her, meanwhile, in the face, and would probably have strangled her, were it not for the timely arrival of assistance.

The young of this species are peculiar; instead of being black, as is the parent, they are of an olivaceous color, ornamented with a dorsal series of dark-edged brown spots, with lateral rows of spots of still darker color. The head is a dark chestnut shade, mottled with brown.

Pennant's early description of this form illustrates the tendency to exaggerate, evinced by many old writers; an inclination, by the way, which has not entirely passed by. He says: "Many ridiculous frights have happened from this innocent reptile. As everyone in America is full of the dread of the rattle-snake, they are apt to fly at the sight of any of the serpent kind. This pursues, soon overtakes, and, twisting round the legs of the fugitive, soon brings him to the ground; but he happily receives no hurt but what may result from the fright; all the mischief this species does is to the housewives, for it will skim their milk pans of the cream, and rob their hen-roosts of all the eggs."

Closely related to the black-snake is the coach-whip snake, *B. flagelliformis*, which inhabits the south, as far west as the Mississippi, where its variety, *testaceum*, extends

to the Pacific. The general form is greatly elongated, resembling in this respect some of the Dendrophidæ, as specimens are sometimes six feet in length. They are most beautiful animals, and so fleet in their movement as to almost fly over the ground. Though ordinarily inoffensive, on being attacked they defend themselves with vigor. Batram, in his "Travels in Carolina," speaks of once finding a hawk so wound up by one of these serpents as to be rendered almost helpless. The name 'coach-whip' is not given because of the elongated body, but from the arrangement of the juxtaposed caudal scales, which resemble a braided raw-hide whip. Catesby mentions a peculiar belief, among the Indians, that the snake will, by a jerk of its tail, separate a man in two parts; and the negroes of the south, to-day believe that it can flagellate a man to death. *B. teniatum* is found from the plains to the Pacific. While *B. constrictor* has the scales of the back in seventeen rows, *B. teniatum* has them in fifteen, and is, moreover, ornamented with a brown dorsal band and with lateral lines of orange, red, or yellow. The inferior surface is anteriorly spotted with brown.

The genus *Spilotes* is represented in North America by two species which differ from the members of the previous genus in having the teeth equal and smooth — the 'black-snakes' have them larger posteriorly. *S. couperi* inhabiting the Gulf states and Georgia, from its enormous size, is the most interesting form. In coloring it is of a deep black, shading into yellow on the throat. It is known by the negroes as the indigo or gopher-snake, and, though sometimes reaching the enormous length of ten feet, it is never molested by them, as they suppose it to be, like the king-snake (*Ophiobolus getulus*), a mortal enemy to the rattler.

Pityophis has the scales keeled, the nasal plate divided, and the last abdominal plate entire. *P. melanoleucus*, the pine or bull-snake, is found east of the Mississippi and south of the Ohio rivers, and it is particularly fond of the pine forests. Though one of the largest North American serpents, it is extremely active, disappearing almost instantly on being surprised, though this may be due to the fact that it not unfrequently has underground holes into which it retreats, and from the immediate vicinity of which it seldom journeys. To obtain its prey it chooses a likely locality, and waits in patience for some unsuspecting rabbit or squirrel to pass by. *P. bellona* inhabits the west, feeding, as do many of the genus, on mice, gophers, and other small vermin, and doing, in this way, immense benefit to the agricultural interests, as the gophers, as well as other small rodents, are perfect pests of the western farmer. The western bull-snake not unfrequently exceeds the length of six feet, but it is of a peaceful disposition. Captured individuals of this species have been known, even when concealed, to attract others. It is not an unusual occurrence for the mate of a serpent which has been killed to search for, find the body, even when it has been dragged for some distance, and remain by it apparently with a feeling of sorrow if not of revenge.

The Indian rat-snake, *Ptyas mucosus*, is very abundant in southern India and Ceylon, where it often enters human dwellings while in pursuit of rats or chickens. It is always ready, on the slightest irritation, to bite, and, as it grows to a considerable size, often reaching seven feet in length, it gives considerable annoyance to the natives. When angry, the rat-snake is said to produce a peculiar musical note not unlike that of a tuning-fork. In general structure it resembles our common black-snakes.

The genus *Dromiscus* is common in the West Indies, South America, and Mexico. A single species, *D. flavilatus*, has been found in the southeastern United States, there being in the National Museum a single specimen from Florida, and a second from North Carolina. *D. ater* is the 'gray-snake' of Jamaica, and is often seen about

old ruins, lurking in some cranny for the approach of an unlucky lizard. If irritated, it will dart at its adversary with all the savage vehemence of the most venomous moccasin, and, as it strikes for the eyes, its attacks not unfrequently prove dangerous.

Zamenis includes those Old World snakes, found about the Mediterranean and in India, which generally have the last maxillary tooth enlarged and separated from its fellows by a short interspace. Of the genus *Xenelaphis* but a single species has been described; a few specimens, some measuring six feet in length, have been captured in the East Indies. *Philodryas viridissimus*, a most beautiful example of the Colubridæ, and connecting them with the Dendrophidæ, inhabits Brazil, where, because of its slender body and beautiful green color, it has received the name of emerald whip-snake. It lives on young birds, and on such small prey as it may capture while meandering among the branches of the tropical forests.

The members of the family Dendrophidæ, or tree-snakes, are found sporting amid the luxuriant foliage of tropical America, Asia, and to a less extent, Africa and Australia. To adapt them for an arboreal life, the body and tail is greatly elongated, and each ventral scute is usually provided with a pair of keels by which the animal can the more firmly grasp the smooth branches. The genus *Dendrophis* includes a large number of species, which are frequently adorned with the brightest colors, of which green is often the prevailing tint. The head, which is distinct from the neck, is narrow, long, and depressed, the snout being very prominent. Two species, representing two genera, are natives of Mexico, *Leptophis mexicanus*, and *Oxybelis æneus*, which latter species, though of small diameter, reaches a length of four feet. The Boom-Slange, *Bucephalus capensis*, of South Africa, presents so much variation in its marking that several species have been described by those unprovided with a sufficient number of specimens. Though the inhabitants of South Africa consider this form to be poisonous, on dissection no venom glands have been found, though the teeth are covered with a slimy secretion, which may be possessed of irritating qualities. Allied to *Bucephalus* is *Ahætulla liocercus*, one of the most beautiful of tree-snakes, inhabiting Borneo, where the native children are said to often make a pet of it, the harmless reptile coiling around their arms and bodies without their evincing the slightest alarm and naught but pleasure. In its native haunts the animal is most active, leaping from branch to branch of the highest trees, and directing its lithe form with lightning celerity towards any unfortunate lizard or beetle which it may chance to espy. Living also in Borneo, as well as on neighboring islands, is the larger *Goniosoma oxycephalum*, which reaches a length of eighty-two inches. It is said to be a most active and ferocious animal, defending itself, when attacked, with great energy.

The tree-snakes proper are included in the genus *Dendrophis*, and are characterized by having an obtuse snout, equal teeth, and smooth vertebral scales. *Dendrophis picta* is the most common East Indian form, and, like *Bucephalus*, it is liable to great variation in color. *D. punctulata* is a beautiful animal inhabiting Australia, and growing to a length of five or six feet. It is of an olive-green color above, and pale yellow below; the shades of color, however, appear to depend on surroundings, as specimens in captivity are never so brilliant as those seen gliding along the grass-land, or swinging from branch to branch of the lofty trees. The nearness to the time of exuviation has also considerable to do with the coloring; specimens just after the old epidermis is shed being very brilliant. The eye of this form is large; the teeth small and of uniform size, and the dorsal row of scales considerably exceeds in size those of the scales of the body. A loreal, a scale generally characteristic of this as

well as of other innocuous ophidians, is present, and the assumed shape of the body when the animal is angry is compressed, instead of depressed like that of venomous forms, of which the laterally extended neck of the *Naja* presents the best type. It seldom attempts to bite, and can be ordinarily handled without showing any resistance. The food consists of batrachians, saurians, young birds, and possibly insects. It is probably oviparous, and is found in all but the southern portion of the Australian continent. *D. calligaster* is a more northern form. It is small, not reaching a length of three feet, has no loreal shield, and below is purplish-yellow.

Chrysopelea orna, because of the innumerable varieties of marking which it presents, almost defies specific description. It is considered by Günther to be the most beautiful of all snakes. In its habits it is arboreal, being able to even pass down a smooth and vertical tree-trunk. It is a widely-distributed form, inhabiting southern Asia and the East Indian archipelago. Its food consists of geckoes and other small saurians.

The family Dryophidæ includes some of the most interesting forms of the serpent tribe. In the genus *Dryophis*, not only is the body so slender and elongated as to reach a length of nearly five feet, with a diameter of less than an inch, but the head is also slender, with the muzzle projecting for some little distance as a pointed proboscis. Representatives of this group are found in Asia and America, though the most interesting form inhabits Madagascar. The Old World species have the maxillary teeth grooved, while the American forms have them less specialized. The prevalent color is green, with two longitudinal white stripes along the lower side. The longer diameter of the pupil is horizontal, a position which possibly points to the nocturnal habits of the animal.

The most remarkable representative of the family is the langaha, *Dryophis langaha* of Madagascar, which, though its body is less than three feet long, has a scaly proboscis, often flattened into a leaf-like organ, half an inch in length. The general color of the animal is a deep brown. *Tragops prasinus*, or as it is sometimes called, *Dryophis nasutus*, is a beautiful grass-green animal, living in the jungles of India, and often reaching the length of seven feet. To it has been attributed the habit of darting at the eyes of passers-by, an action which has made it particularly disliked by the natives. The snout is greatly prolonged, and provided with a movable fleshy tip.

Passerita has the snout much produced, as in langaha. That this development is used merely as a tactile organ, such as are the tentacles of *Herpeton*, is questionable. While *Herpeton* is semi-aquatic, and would find tentacles, which would do away with the necessity of it protruding its tongue, a most useful acquisition, *Passerita* is an ordinary tree-snake in its habits, so that its tongue can, unhindered, perform its ordinary functions. The rostral prolongation is moreover covered with rough scales, and can only be imperfectly sensitive. It seems that the true office of this development is to increase the size of the opening of the mouth, as do the marginal bristles of the mouth of some birds — for example, the night-hawks (Caprimulgidæ).

The Natricidæ, which includes many of our most common snakes, unites forms so diverse that clear definition is almost impossible. It includes serpents which may be small or large, slender or stout; the eyes are of medium size; the teeth variable; and the scales either keeled or smooth. The several genera are well circumscribed, though the family is difficult to define. They prefer the neighborhood of water, in which, if the case demands it, they are expert swimmers. They differ from many other Colubriform snakes in their habit of beginning the process of deglutition as soon as their prey is

seized, without first waiting for it to die. This habit has often resulted in considerable interest to those unfamiliar with it. Not infrequently the snake can be induced, on irritation, to disgorge a well-secured meal, which often appears as a lively frog, that hops away with all the experience, if without the understanding, of Jonah. The habit may also explain the almost universal belief, of which more has been said in the introduction, that certain snakes swallow their young in time of danger. Since a serpent, that had been made a meal of would live for some little time after being swallowed, and if, in the meantime, the feasting snake were killed, the imprisoned animal would, if liberated, crawl away with all the experience of the frog.

We will first treat one of the largest genera, and the one that is the most typical of the family; its members are recognized by their keeled scales, regular arrangement of the cervical plates, and by the numerous teeth of the jaws and palate, of which the

FIG. 216. — *Tropidonotus natrix*, 'common snake' of Europe.

anterior are shortest. The *Tropidonoti* are found in the neighborhood of water, as a general rule, and, though not aquatic, are excellent swimmers, and, on being surprised, will often choose this means of escape. Members of the genus are abundant in North America, Europe, Asia, and a portion of Australia, as well as some of the islands of the Eastern Archipelago, though rare in Africa and South America.

The illustration which has been selected to represent this large genus is that of *Tropidonotus natrix*, a form which is abundant throughout Europe, being particularly fond of the neighborhood of ponds and streams, into which it often voluntarily plunges, sometimes coiling itself up and remaining at the bottom for hours at a time. With the common people it is known as the ringed or grass-snake, and is often tamed, soon learning to distinguish its friends. In confinement it will eat beetles, grasshoppers, frogs, and even bread and milk. Of the dozen or more American representatives of this genus, *Tropidonotus sipedon* is, perhaps, the most familiar. This snake is found in

the vicinity of nearly every slow-running stream, brook, or pond, where they often startle the angler, either by their exertions to escape in the rushes or semi-aquatic bushes, or by boldly plunging into the water, in which they also often capture their food, which consists of frogs, toads, or fish, and, being excellent swimmers, they are not infrequently seen in the middle of ponds, and are especially abundant about lily-pads. They are said to frequently take the hook, when it is baited with a worm or small minnow, but when captured will fight like a tiger. In many portions of the south this snake is called the water-moccasin, and is considered very poisonous. While dying, the lower side of the body often takes on an iridescent character, the rapid changes of the prismatic colors being particularly beautiful. Specimens over three feet in length are rare. The Australian fresh-water-snake, *T. picturatus*, varies much in color, being either gray or deep brown, with a salmon-colored abdomen, and spotted along the sides with a double series of red dots. It resembles, in general marking, the *Tropidechis*, a venomous form; the two can easily be distinguished, however, as *T. picturatus* has fifteen dorsal and lateral rows of scales, while *Tropidechis* has more than twenty. The species under consideration has been observed to congregate in great numbers, during the early evening, around lagoons and water-holes, though during the day few or none are to be seen. Of the score or more of Indian *Tropidonoti*, *T. macrophthalmus* is the most interesting form, for, though it is a perfectly harmless animal, it superficially resembles the cobra so exactly as to often deceive those well acquainted with both animals. The resemblance is further carried out in that the neck is capable of expanding horizontally, and is provided with a larger number of scales than is the rest of the body. This animal, inhabiting the Himmaleh mountains, offers one of the most interesting instances of protective resemblance in the animal kingdom.

Also abounding in species, of which, in North America alone, there are about a score, is the genus *Eutænia*, to which our most familiar serpents belong. *E. saurita* and *E. sirtalis*, are seen by the dozens, during a country walk, of a bright summer's day, anywhere in the more eastern portions of the United States. In general marking the two so nearly resemble each other that they are ordinarily considered to be similar, being popularly called striped or garter-snakes. *T. saurita*, however, is longer and much more slender than *T. sirtalis*, and is found in more moist localities. The collector will capture many more of these forms than of any other, except, possibly, the green-snake. The eggs of *Tropidonotus* are sometimes found about out-buildings, and in hatching give birth to little fellows having enormous eyes and a spotted body, the longitudinal bands of the adults only being gained after several sloughings of the skin. These cast-off skins are very abundantly found among piles of rubbish, or under the loose bark of decaying trees. They are eagerly sought after by the great crested fly-catcher, *Myiarchus cristatus*, who uses them to line her nest. Though perfectly harmless, the garter-snakes are most offensive to handle. They exude a most fœtid odor, which so possesses the power of penetration and adhesion as to render it quite impossible to rid one's self of it.

The genus *Storeria* is represented in the eastern United States by two species, both of small size, though interesting and graceful in their habits and motions. *Storeria occipitomaculata* is found throughout the Mississippi valley, and eastward, and is often captured in New England, where it has been called the spotted-necked-snake, on account of the three large, white, irregular blotches just back of the occipital plates. *S. dekayi* is equally abundant, and was first described, as was the previous species, from Massachusetts specimens. It frequents meadows and grass-ground, where it

feeds on insects, such as grasshoppers and crickets. *Helicops*, though a tropical genus, is represented in Florida by Allen's *Helicops*, a form which, because of the peculiar structure of the tail, stands well up, and perhaps should lead the genus. *Abastor erythrogrammus*, the so-called hoop-snake, though it possesses none of the remarkable qualities attributed to this monster of tradition, is an abundant species in the south. Though preferring damp and marshy ground, it never voluntarily takes to the water. *Farancia abacura*, inhabiting the south from the Carolinas to Texas, is a closely related form, though it is more shy and, consequently, apparently less abundant. It lacks the longitudinal dorsal ornamentation, and below is of a deep red color. It is called horn-snake by the negroes.

The family of desert-snakes, PSAMMOPHIDÆ, are chiefly inhabitants of tropical Africa, and are not very well known. In some points of structure they resemble the Dryophidæ, though members of this latter family can always be distinguished by their green coloration, and by their horizontally placed pupil: the desert-snakes are, moreover, provided with a pair of long maxillary teeth. *Psammophis elegans* is long and slender, though the other members of the family are stout, and adapted for a terrestrial life. *P. pulverulentus* is a most repulsive reptile; its undefined ornamentation, swollen lips, and large, hidden fangs, give to it, on examination, a most venomous aspect. It is a small species, inhabiting southern Asia, and the neighboring islands. *Cœlopeltis lacertina* inhabits Egypt.

The HOMALOPSIDÆ includes fresh-water snakes, which sometimes swim down the rivers to the sea, and in general structure resemble the truly marine snakes, Hydrophidæ, with which they have sometimes been classified. They have the nostrils so placed upon the tip of the snout as to enable them to breathe without protruding but a small portion of the head from the water. They prey on fish and crustaceans, often lying in wait, their prehensile tails being entwined around some submerged branch; in captivity, however, they generally refuse all nourishment and soon die, otherwise they would make extremely interesting pets, being gentle and harmless. It is stated that the act of parturition is performed in the water, the known species being viviparous. The most interesting form is *Herpeton tentaculatum*, a species which, though often figured, is extremely rare, a single specimen having been unique for more than half a century, and now the species is only rarely seen in herpetological collections. It inhabits the southeastern portion of Asia, where it is occasionally found in muddy water, its tentacles serving as organs of touch. These rostral appendages are as long as the snout, and are covered with scales similar to those of the loreal region.

Hypsirhina is characterized by its smooth scales and united frontal plates. The species, about six in number, are restricted in their distribution to the East Indies. Cantor gives an interesting description of a specimen of *H. enhydris*, which he succeeded in keeping for a considerable time in captivity. "Members of this species may be seen in rivers as well as in irrigated fields and estuaries, preying upon fishes, which, however, it refuses in a state of captivity. It is of timid and peaceful habits. A large female, after having been confined upwards of six months in a glass vessel filled with water, brought forth eleven young ones. Shortly after the parturition she expired, under a few spasmodic movements; and also two of the young ones died in the course of about two hours, after having, like the rest, shed the integuments. In length they varied from six inches to six and two eighths. The living nine presented a most singular appearance; they remained a little way below the surface of the water, coiling themselves round the body of an adult male which was also kept in the vessel,

occasionally lifting their heads above the surface to breathe, at the same time resisting the efforts of the senior to free himself. Fishes and aquatic insects were refused, in consequence of which the young ones expired from inanition in the course of two months."

The family RACHIODONTIDÆ is represented in Africa and possibly in Asia. *Dasypeltis inornatus* is frequently found under the bark of trees in the southeastern portions of Africa and presents one of the most interesting examples of adaptation for a special end. The Rachiodon has a general structure which enables it to lead an arboreal life, searching among the branches of the tropical trees for birds' eggs, and that the contents of the egg may not be prematurely freed while it is yet in the mouth, teeth are absent except in the angle of the jaws where they cannot reach the shell. When the egg reaches the œsophagus it comes in contact with a row of "vertebral teeth," formed by the specialized inferior spinous processes of the first seven or eight cervical vertebræ, which are elongated and covered with enamel; by contraction of the muscles of the throat, these saw through the egg, the contents passing on to the stomach, while the limey shell is quickly ejected. *Elachistodon westermanni* is the Indian form. Though provided with the same peculiar vertebral teeth it is probably a member of another family.

The DIPSADIDÆ, or night tree-snakes, includes a large number of serpents inhabiting the tropical regions generally, having an elongated compressed body, broad and triangular head, and with the posterior maxillary teeth grooved. In the New World a single species passes north of Mexico into Arizona and Texas, though other representatives are quite abundant further south, the genus *Leptognathus* reaching the Argentine Republic. *Dipsas* is found in Mexico and Brazil, as well as in India, Africa, and Australia. It is from a most strange and ancient belief that the genus has been thus named. *Dipsas*, which is derived from a Greek word meaning thirst, was given to this harmless reptile from the belief that the animal was possessed of a most insatiable thirst, to alleviate which it would often coil itself in the valuable springs of the deserts, polluting their water and imparting to their victim, should they sting the unfortunate traveler, an eternal thirst which could only be quenched by death.

Dipsas dendrophila is of large size, sometimes measuring seven feet in length. It is of a deep black color with numerous yellow cross-bars, which in some specimens are reduced to lateral spots. The lower portions are usually yellow, marbled with black. The species properly belongs to the East Indian archipelago, though it is occasionally found on the mainland about the Malay peninsula. Of the Indian *Dipsades* proper it is worthy of note that they capture only warm-blooded animals, some being exclusively bird and others mammalian feeders. A single species, *D. fuscus*, inhabits Australia, and a closely related form is found on the island of New Guinea. Though the posterior maxillary tooth is long and grooved, the bite is not the least dangerous. Being nocturnal in their habits, they are not so abundant in collections as are their diurnal cousins the Dendrophidæ, though specimens have been taken all along the eastern coast, where, coiled up in the branches of some tree, they await the approach of night, when they sally forth to search for birds' eggs, insects, frogs, and the smaller Mammalia. In captivity they are said to be gentle, allowing themselves to be freely handled without evincing the slightest inclination to resist.

The blunt-head or *Amblycephalus boa* of Java, Borneo, and the neighboring islands, though classified among the Dipsadidæ, is an aberrant form; the head has

been compared with that of a dog, which animal it further resembles in its habit of snapping at whatever disturbs it. It often secretes itself in the thatched roofs of huts, where it finds a large assemblage of insects. The genus *Pareas* includes a few species inhabiting Java, and neighboring islands, which have the palatine and mandibular teeth gradually increasing in length from behind forwards.

The members of the family Scytalidæ are closely related with those of Dipsadidæ. But three genera are known. *Oxyrhopus clœlia* and *doliatus* are found in Mexico, *Hologerrhum* inhabits the Philippines, and *Scytale* South America.

The family of Lycodontidæ embraces a number of snakes of moderate length, with small eyes and generally vertical pupil. The shields of the head present nothing extraordinary; the dentition alone being prominently characteristic. The maxillary armament has anteriorly a pair of elongated teeth.

Fig. 217.—*Scytale coronata.*

From the peculiar shape of the pupil of this family it would seem that the members are nocturnal, yet this is not the case with most, as they feed almost exclusively on skinks, which can only be captured during the day. Some African Lycodonts are, however, nocturnal, feeding on mice.

The genus *Lycodon* includes some of the most common snakes of India, *L. aulicus* being perhaps the most abundant. The fangs in the front of the jaws admirably adapt this animal for seizing and retaining the small hard-skinned saurians which form almost its only food. It is a small animal of only about two feet in length.

The highest family of colubriform ophidians is made up of the wart-snakes, Acrochordidæ, which are disposed in three genera. *Acrochordus javanicus* has the body covered with small, wart-like, tubercular or spiny scales, no shields on the head, and no specialized ventral scutes; the tail is short and prehensile; the nostrils close together and at the tip of the snout. It is viviparous, as are the other members of the family,

as many as twenty-seven young being born at a time. Very few of these animals have ever been taken, though they are occasionally seen on the island of Java at Penang or Singapore. The savage appearance presented by its sullen eyes, swollen jaws, and short, thick body, is not such as would court a more intimate acquaintance. Allied to the preceding and also inhabiting the East Indies is *Chersydrus granulatus*, which has the hinder part of the body and tail slightly compressed, and its lateral surface increased by an inferior fold of skin along the abdomen and tail. The scales are

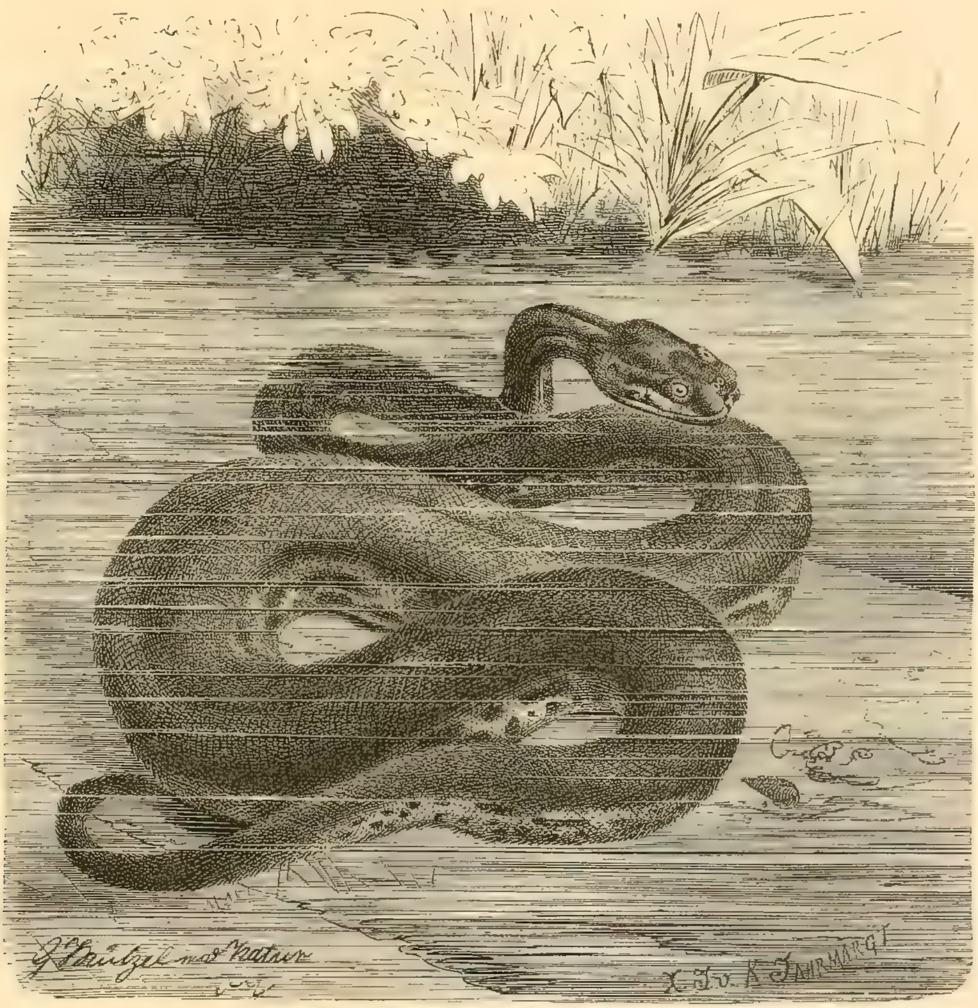


FIG. 218.—*Acrochordus javanicus*, wart-snake.

unprovided with the tubercles and spines of the previous genera, though both forms are alike in having no ventral scutes. This, as might be inferred from its structure, is a purely aquatic reptile, resembling in its habits the Hydrophidæ, though it lacks the prolonged processes of the caudal vertebræ, and its bite is perfectly harmless. *C. granulatus* is found along the shores of the Eastern archipelago, New Guinea, and the Philippines, as well as on the east coast of the Indies, sometimes being found several

miles from land. *Xenodermus* differs from the other, the two already mentioned Arcrochordidæ in having well-developed ventral shields, and sub-caudal scales. It inhabits Java.

SUB-ORDER III. — PROTEROGLYPHA.

We now come to the snakes provided with poison-fangs; they have been divided into two groups, viz., those with permanently erect fangs, Proteroglypha, and those having fangs which can be erected or depressed at will, Solenoglypha.

In the first group, behind the erect grooved fangs is the usual armament of maxillary, palatine, pterygoid, and mandibular teeth, and the general form and external armature of the body generally resembles that of the Colubriformia. There are two families, the distinction being based on the general shape and structure of the tail.

The family ELAPIDÆ has the body cylindrical; the tail fusiform; the head with the usual armament of shields, though the loreal, with the exception of a single species, is always absent. The eye is small and has a round pupil, and the nostrils are placed laterally, while in the succeeding family they are, except in *Platurus*, placed dorsally on the tip of the snout. The fang is not only perforated by an internal canal which conducts the venom from the specialized salivary gland to the slit-like opening in the distal extremity, but along the front is a permanent groove. Members of the family inhabit all the tropical countries as well as, and especially, Australia, and are generally regarded with considerable fear by the natives.

The introductory species is the cobra of India, or, as it is known to science, the *Naja tripudians*, and is the most familiar, as it is the most dreaded, of the serpent tribe. Though *Ophiophagus*, of the same country, is the most venomous of ophidians, the naja is more abundant, and, being extremely poisonous — it being estimated that the annual mortality in the Indian peninsula, from its bite, is over 5000 — is more feared than any other reptile. Though several varieties of this dangerous animal exist, there is in India but a single species, which is also found throughout the islands of the Malay archipelago. While hunting for its food, of small reptiles, frogs, and fishes, it may climb to the roofs of huts, among the limbs of trees, or even enter the water, where it is an expert swimmer, being sometimes found at a considerable distance from land. It is often nocturnal in its habits, and is ovoviviparous. Its natural enemies are jungle-fowl, which devour the young, and the ichneumons *Herpestes*, which will overpower the largest adults.

The cobra-da-capello, being the most common venomous reptile of India, an object of curiosity to the Europeans, the sole source of subsistence of innumerable vagrant snake-charmers, and an object of intense interest to naturalists, has probably received more attention than any other ophidian, not excepting the rattle-snake. Those bitten by the animal seldom escape death, and, of the few that do, many are subject to periodic returns of the most excruciating pain. Ordinarily, on being attacked, if no antidote is administered, the poison almost instantaneously affects the whole system. The reptiles seem to be well aware of the fatal power possessed by themselves as well as by their fellows, for while, in confinement, they will attack and kill any snake of a different kind that may be presented, for their own species they evince the greatest respect, though, when several are closely confined in the same apartment, trouble may occur. They soon become accustomed to menagerie life, and often live to an old age. When thus confined, the animal, during the day, is lazy and inactive, seldom stirring

except when irritated, or to occasionally drink; at night it is active and restless. The front of the glass cage containing these animals at the Zoological Gardens in London has to be painted, that the serpents may not kill themselves by striking against the otherwise invisible obstacle when irritated by visitors.

In its general form the *Naja* differs from other snakes, excepting the related *Ophiophagus*, the superficially similar *Tropidonotus macrothalmus*, and a few Australian forms, in possessing a dilatable neck, the ribs of which are greatly elongated and flattened. The reptile, when excited, is capable of expanding the neck to a width several times exceeding that of the head, the cervical scales being much more numerous across the back of the thus formed 'hood,' as the expanded portion is called, than they are further down the body. The hood, in the ordinary form, is ornamented with a pair of dark spots on its upper side, which, being connected by a cross-bar, bear a strong resemblance to a pair of spectacles, from which fact the animal is not infrequently known as the spectacle-snake. The explanation of the origin of this ornament as given by the superstitious Buddhists, who always treat the reptile with the greatest reverence and behold its maltreatment with horror, is that Buddha, weary with his labors, was lying asleep in the direct rays of the sun, when, seeing which, a cobra so elevated himself and expanded his hood as to shield the deity. On waking up, Buddha was so pleased with the act that he promised to repay the considerate reptile, which promise, however, he soon forgot. It seems that at this time a kite preyed on the cobras, and to such an extent that a total extinction of the race seemed inevitable; in despair, and as a last resort, the cobra ventured to remind the god of his promise, and begged protection from the enemy of his race. Buddha then placed the black marks on his hood, which so surprised and frightened the kites as to render the cobras forever free from their attacks. This attributed act of protection has so influenced the ignorant natives that they do not dare protect themselves from an animal which is yearly killing off thousands of their race.

The fangs of the *Naja* are long and grooved, having the foramen at their extremity so situated that the slightest scratch will prove inoculative. Behind the fangs are a few ordinary teeth. In coloring the reptile varies greatly; it may be of a uniform brownish-olive above, with white, black-edged 'spectacles;' uniform dark brown with black spectacles; blackish-brown with a pair of white spots in place of the spectacles, or it may even have no marking on the neck whatever; or a uniform black, with a single white ornamental spot, and white or black below. These differences in coloration and ornamentation belong to a single species, which, as Günther says, "is only too common all over the continent of the Indian region."

The only relatives of this animal are the *Naja sputatrix*, a black, unornamented form, and the asp (*Naja haje*) of the Egyptian divinities, an animal found in northern Africa, and called by the residents Spurge-schlange, because of the peculiar habit attributed to it of forcibly ejecting its venom, which may often reach the object of the serpent's anger, though it be some little distance away. Mr. Cumming, the African explorer, speaks of suffering great pain from the poison which one spat in his eye. That this is an ordinary habit of the snake is rather doubted by some naturalists. The asp is described as being generally slow in its movements, though, when irritated, it flies at its adversary, defending itself with great energy. It is a good climber, and quite often is seen in the water, where it is perfectly at home, which habits are those of the cobra, an animal which it resembles also in coloration and size.

Of snake-charming, of snake-charmers, and of Indian jugglery, a volume might be

written. It seems certain that cobras of the most poisonous nature are handled with impunity by itinerant jugglers, and it is also a fact that not uncommonly the reptiles are rendered harmless by having their fangs extracted. So-called jugglers have been known to capture cobras while they were in their native retreats, and have not been injured, while others, more unfortunate, have been bitten and only saved from death by the prompt administration of some plant, or, to them, charmed stone. The truth about the matter seems to lie in the fact that the cobra, like many innocent snakes,

FIG. 219.— *Ophiophagus elaps.*

will permit itself to be handled in the roughest manner, provided no sign of fear is shown by the person so performing. Perfect confidence and conscious ability will work wonders. It is a peculiar fact, and one that has been paralleled in several American serpents, that when a cobra is destroyed, its companion will soon appear. Pliny, in speaking of this trait, says that between the male and female an affection exists, and if one is killed the other endeavors to avenge its death.

Ophiophagus elaps, though being provided with an expansion of the neck similar

Naja tripudians, cobra-da-capello.

to that of the cobra, has also around the occipitals three pairs of very large shields, which are characteristic of the genus; it is further peculiar in having a single small tooth behind the fang. We are now dealing with the most deadly of animals, a form, the bite of which will produce the death of a human being in three minutes, and that of an elephant in two hours. Were it as abundant as the cobra it would soon depopulate the country, but the *Ophiophagus* is a rare snake, though of wide geographical range. It has been captured in India, Java, Sumatra, Borneo, and other neighboring islands, and is not only the most deadly, but the largest of venomous, colubriform ophidians, specimens having been known to reach the length of fifteen feet. A specimen from India, exhibited before the Linnean Society of New South Wales, measured 142 inches in length. As its name implies, the *Ophiophagus* lives on other snakes, which, as it is very strong and active, as well as possessing such virulent qualities, it has little trouble in overpowering. It is often arboreal in its habits, spending a portion of its time hid away in the hollows of decayed trees. It presents as great a diversity of color arrangement as does the cobra.

The genus *Diemenia* includes several Australian forms which have fifteen or seventeen rows of smooth scales; the fangs provided with anterior grooves, and followed, posteriorly, by a series of smaller teeth. A few of the forms, when adult, are very dangerous. The gray-snake, *D. reticulata*, reaches a length of thirty inches, and is uniformly gray above and greenish below, the underlying skin being black. The eye has two circles, one of black and the other of yellow, surrounding it. Members of the genus are very abundant throughout the Australian continent, with the exception of the extreme north and south, and offer an excellent illustration of the little value that can be placed upon color as a distinguishing character among reptiles. A snake, after shedding its skin, has a much different color from that before exuviation. The gray-snake frequents sandy plains, where it captures small reptiles, and where it also deposits its eggs, sometimes to the number of twenty. It is ordinarily between two and three feet in length, and though some of its congeners are poisonous its bite is said to cause but little irritation. During the cold season, as the gray-snakes are extremely susceptible to frost, they retire, sometimes several together, beneath flat stones, which are daily warmed by the sun, and there remain semi-torpid, often for several weeks at a time. *D. superciliosa* is nearly double the size of the gray-snake, with which it is very generally distributed, though it prefers more rocky localities, where, not infrequently, it proves a dangerous animal. Though the adults retire into the ground during the cold season, the young are found, as are those of many other snakes, under stones and logs throughout the year.

The north Australian *Pseudonaja nuchalis* has the smooth scales arranged in seventeen rows, along the back and sides, while on the non-distensible neck there are two or four more. Behind the fangs there is a series of five or six small teeth. The general color of this rare animal, which sometimes reaches the length of nearly six feet, is brown or blackish-olive, with darker cross-bars, of which the first is of the most intense shade, being in some old forms, the only persistent ornament.

We now come to the genus *Elaps* which, though represented in Africa, South America, and the East Indies by many species, in North America there is but one, which, however, has several varieties. The *Elapides* are characterized by having the head rounded and depressed, and not separated from the body by a distinct neck; the muzzle is short and broad; the fangs stand alone in the upper jaw; the scales are smooth, and so colored as to form bands of the brightest shades of black, red, or yellow,

from reference to the arrangement of which the several North American species can be determined. *Elaps fulvus*, the harlequin-snake, or 'viper,' has the first broad ring behind the occiput black, and all subsequent rings separate, and not united into groups. The head and tail are ringed with black and yellow, while the body combines with these colors a most deep and intense red, the yellow serving as a narrow border for the black. Its habitat is the southern United States and Mexico, though the species is continued still further south by varieties, of which there have several been recognized.

The harlequin-snake is often found below ground, and especially in sweet-potato

FIG. 220. — *Elaps corallina*, coral-snake.

fields, where they are frequently dug up by the laborers. From their ordinary mild disposition they are considered by most people as perfectly harmless, a strange fact when we consider the habits of its more southern congener, *E. lemniscatus*, a most dreaded reptile of Brazil. *E. euryxanthus*, the Sonora harlequin, has the first hood-ring behind the head of a deep red color; it inhabits the Sonoran region, or that portion of south-western United States and northern Mexico which includes a part of Nevada, New Mexico, Arizona, and Sonora in Mexico. *E. laticollaris* is found in the neighborhood of Pueblo, Mexico, and is characterized by having the black rings arranged in groups of threes, and the occipital band yellow. *E. elegans* and *decoratus* also inhabit Mexico; the first has the occipital band black, while *decoratus* has it red.

It should be borne in mind that there are perfectly harmless snakes that have the general coloration of the *Elapides*, though belonging to the previous sub-order. By those unfamiliar with their nature these harmless forms are also called harlequins.

Allied to the harlequin-snakes is the genus *Bungarus*, the several species of which inhabit India. The generic title is a so-called Latin form of the vernacular name, bungarum. The representatives are terrestrial forms, living chiefly on small mammals and reptiles, for which they are continually searching during the day, though they avoid the direct rays of the sun. They are shy, and invariably seek a retreat on being surprised, though they are active on being attacked, defending themselves with great

FIG. 221.—*Bungarus fasciarus*, bungarum.

vigor. Their bite is extremely dangerous, though the degree of its virulence depends on the age of the reptile, as well as on the size and position of the wound. As the fangs are short, the abrasion can generally be excised or cauterized, which should always be done immediately, though the dangerous symptoms are not likely to show themselves until the lapse of considerable time. The largest *Bungarus* reaches a length of four feet, and inhabits Java, the Malay Peninsula, Penang, and portions of China. It is known in science as *B. fasciatus*, and much resembles *B. ceylonicus*, which is abundantly found in the island from which it receives its specific name. From the stomach of this Ceylon species, specimens of *Uropeltis* have been taken.

Hoplocephalus includes nearly twice as many species as any other Australian genus.

The several representatives are viviparous; have their scales smooth and arranged in from fifteen to twenty-one rows; the head not separated from the neck; and the sub-caudal scales entire. *H. curtis*, the brown-banded snake, is the most dangerous Australian reptile, its bite being known to kill an animal the size of a goat in about an hour's time. There is a peculiar fact worthy of mention in regard to this animal. Though its bite proves so immediately fatal to animals generally, to itself or to any other highly venomous serpent the poison has no effect. If the reptile could be poisoned by its own venom, the slightest scar in its mouth would soon become inoculated, and death would result, the animal soon becoming extinct. Experiments of a similar nature on other venomous snakes would reveal many interesting facts. The brown-banded snake is very widely distributed over Australia and the neighboring islands, and sometimes grows to be of considerable size, specimens five or six feet in length being sometimes captured. The coloring is variable, ranging from gray to black and with or without distinct bands; the abdomen is ordinarily of a yellow color. The younger forms have the bands much more distinct than the adults; and the Tasmanian specimens have the belly spotted or clouded with gray. Thirty or even more young are brought forth in a season by a single pair, the young presenting as much variety of marking among themselves as do the adults. At the beginning of cold weather all retire into the ground, from which they do not emerge until the temperature is once more suitable. This reptile, together with other large and venomous Australian snakes, has the peculiar habit, when excited or irritated, of raising the anterior portion of its body and spreading its neck, thus assuming the appearance of the cobra of India. Other species which have this habit are *H. superbus;* the black-snake, *Pseudechis porphyriacus ;* and the orange-bellied snake *P. australis.*

The large-scaled snake, *Hoplocephalus superbus*, is easily distinguished from its congener, *H. curtis*, the only form which equals it in size, by the shape of the middle cervical plate, which is oblong, that of the previous species being almost square. The present species, moreover, has the scales of the back and sides in a less number of rows, there being but fifteen, while *H. curtis* may have even nineteen. Specimens have been captured which had markings on the back of the distensible neck which strongly resembled those of the cobra, though ordinarily the snake is unornamented, being of a plain copper color. Like the previous species, the large-scaled snake prefers marshy localities, frequenting extensive reedy swamps or river banks, where it captures frogs, lizards, and small mammals. It inhabits Tasmania, as well as southern Australia, on the island being known as the diamond snake, a fact that has been mentioned in connection with the Australian 'diamond,' *Morelia spilotes*. *H. variegatus* is extremely limited in its distribution, being only found in the immediate neighborhood of Sydney where it is known as the broad-headed snake and reaches a length of three feet. Being a nocturnal form, it is, though abundant, seldom met with by the collector, except under flat stones, where they hybernate during the cold season. It frequents the open scrubby country and is also quite abundant along the coast line of the south-east. Its poison is not of a sufficiently virulent character to produce any serious results to larger animals. Mr. Gerard Krefft, who has done more to elucidate the study of the Australian reptiles than any other naturalist, says: "If a person be bitten by one of them, the simple act of sucking the wound is sufficient to avert any unpleasant sensation; but should nothing be done, a violent headache, a certain stiffness in the spine, and some local swelling is generally the consequence. It takes from thirty minutes to an hour before these symptoms set in." Closely resembling this species, but differ-

ing from it in having the ventrals deeply cut out on each side, is *H. stephensii*, which inhabits the neighborhood of Hastings River. *H. coronoides* is peculiar to Tasmania. *H. nigrescens* is unique in having the tongue white. Though first only found around Port Jackson, it has since been obtained from points along the coast further north. It is closely allied to *Vermicella*, like which ophidian it allows itself to be handled without offering resistance.

Tropidechis carinata resembles in many points the members of the previous genus, but has the scales keeled, which peculiarity, with others, gives it the appearance of some harmless *Tropidonotus picturatus*, from which animal, however, it can be easily separated by counting the number of rows of scales, the venomous snake having twenty-three rows, while *Tropidonotus* has only fifteen.

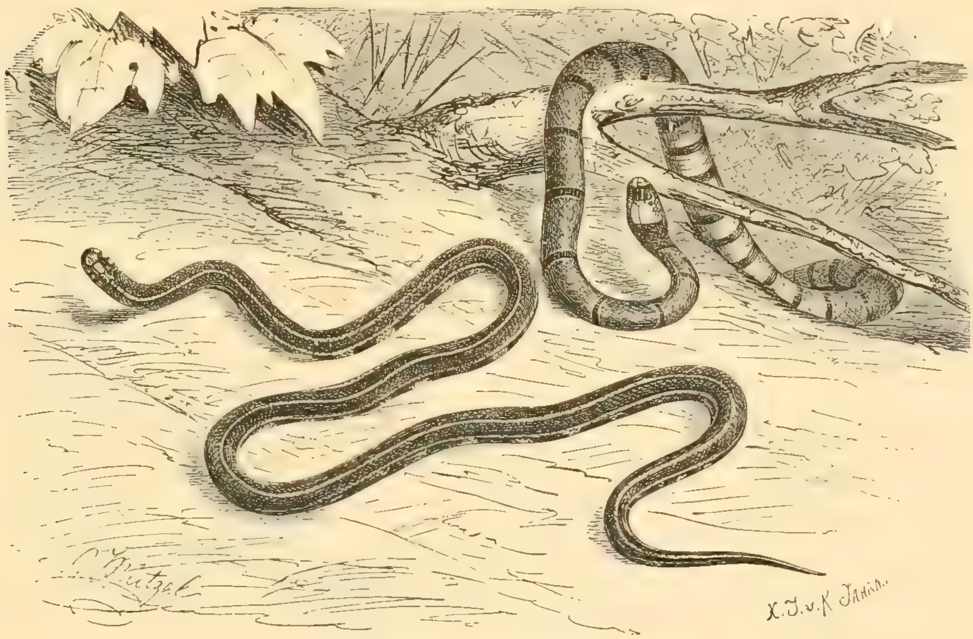


FIG. 222.—*Callophis macellandi* and *C. annularis.*

It has been noticed that venomous snakes often have the temporal shield inserted between the two last upper labials; this arrangement is illustrated by the genus just treated.

The genus *Pseudechis* has the scales arranged in seventeen rows, the anterior subcaudals entire, while the hinder ones are generally divided; behind the grooved fangs are smaller simple teeth. The first species, *P. porphyriacus*, a black snake, grows to a length of six feet and is the most common Australian venomous snake, and was first classified with the cobras by the early writers, being, as already said, one of those ophidians which on irritation expand the skin of the neck. It is fond of moist localities, and is quite active when in the water, where it catches frogs, insects, and small mammals; as many as sixteen young water-rats (*Hydromys leucogaster*) have been taken from its stomach. The bite is extremely venomous, soon producing the death of a fair-sized animal. It is found all over Australia, but has never been captured in Tasmania.

The *Callophides* are characterized by the small number of scale rows, there being only thirteen, and by the grooved maxillary fang standing alone. The several species are very similar to one another. The head is of moderate length, and not separate from the body; the cleft of the mouth is but little extensible, and the scales of the body are smooth and polished. The genus is restricted to British India, and the members are more abundant on the continent than in the Archipelago. They represent the American *Elaps*, the African *Homorelaps*, and the Australian *Vermicella*. They are thus terrestrial forms, preferring the hilly countries to plains, and are of slow and sluggish movement. In their general form they closely resemble the abundant Calamaridæ, on the members of which genus they chiefly feed; the venomous reptile being able to overpower the non-venomous. It is a strange fact that the distribution of these two genera is over the same geographical area, and, though both are abundant in India, a specimen of neither genus has ever been found in Ceylon. The sight and hearing of *Callophis* is extremely defective, making it an easy matter for the collector to secure them. Though they can only be induced to bite after considerable agitation, they are nevertheless very poisonous, and the greatest caution is necessary in collecting or handling them. Animals inoculated with the venom have died in from one to two hours, though the small fangs and scanty supply of poison renders it quite easy, in case of accident, to prevent any fatal results, provided only that the proper remedies are at hand.

One of the most beautiful of Australian ophidians is the scarlet-spotted snake *Brachysoma diadema*. Its general color is brown, each scale having a yellow spot in its centre, and the neck, which is distinctly constricted, is surrounded by a bright scarlet collar. While the scales of this species are disposed in fifteen rows, those of *B. triste* are in seventeen. The genus *Vermicella* has the head like *Elaps*, and a pair of minute grooved fangs, without any other teeth in the upper jaw. These characteristics connect it, as well as allied Australian forms, more intimately with the *Elapides* of the western than of the eastern hemisphere. *V. annulata* is called by the native collectors the black-and-white ringed-snake, and inhabits nearly every part of the insular continent. It is at once recognized by the alternate black and white rings, which encircle the body, and by its peculiar dentition.

The arrow-headed Dendraspis, *Dendraspis angusticeps*, is an inhabitant of South Africa, and is quite abundant at Natal. It is long, sometimes reaching six feet, slender, very active, and a good climber. Its color is olive brown, with green above and a paler shade below. Much different in form is the death-adder of Australia, known to science as *Acanthophis antarctica*. Its popular name is most characteristic, as it is a very dangerous reptile, being provided with long immovable fangs, and possessing venom of a most dangerous character, though not so virulent as that of the cobras or rattle-snakes. A frog severely bitten by a large death-adder has been known to live more than twelve hours. The peculiar tail, the terminal portion of which is compressed, and covered with enlarged scales, the last being formed like a thorn, though it only becomes hard in old individuals, is neither an instrument of offence or defence, though the natives suppose it to be a most effective instrument of death. It is from this peculiar appendage that the generic name has been given.

The genus *Denisonia* is peculiar in having — though it is a poisonous snake — a loreal shield, an ornament which is usually characteristic of innocuous ophidians. It is a rare snake, of only ordinary size, inhabiting Queensland.

The family Hydrophidæ, or sea-snakes, includes a group of highly specialized

ophidians. The elongated body, though sub-cylindrical anteriorly, is posteriorly compressed, the tail often being shaped like a broad paddle. To bring about this structure, the caudal vertebræ are compressed, and their vertical processes elongated. The head is rather 'indistinct' in most of the forms, and bears the valvular nostrils, except in *Platurus*, on the upper side; the eyes are small, with a round pupil; there is no loreal plate, and the general scutellation of the head is regular; the body scales are small, and may be keeled or tuberculate; the fangs are of ordinary size, erect and grooved, and followed by other teeth of simple structure. The members of the family inhabit the tropical portions of the Indian and Pacific oceans, and sometimes enter fresh water. All are purely aquatic, spending their whole life in the water, out of which they appear to be blind and soon die (*Platurus* may be an exception to this statement, as it offers many structural characters opposed to the other Hydrophidæ). In their general form the sea-snakes are most admirably adapted for their aquatic life. The compressed body and paddle-like tail not only point to this, but the belly is not rounded as in other ophidians, but sharp, like that of a herring. The ventral scutes, moreover, not being of value for aquatic locomotion, are not specialized, or, if so, only in a mild degree. The tail, though shaped like that of a fish, is at the same time prehensile, enabling the animal to rest by winding it about some half-submerged root or piece of coral. The nostrils are so provided with valves, that when the enormous lungs have been inflated, they can be tightly closed, and the animal, with its supply of air, can either dive below the surface or rest motionless, being buoyed up by having its specific gravity thus diminished. The position of the nostrils is such as to enable them to breathe without protruding more than the tip of the snout from the water. The armament of scales has been seized upon by the naturalist as offering a means of classifying the several species. While a few have the scales imbricated, like those of terrestrial serpents, the majority have them merely juxtaposed, and often lose their horny covering and become tubercular and soft. The shields of the head (except in *Platurus*, which form is generally exceptional), are so changed as to often lose all resemblance to those of ordinary ophidians. In shedding their epidermis, the sea-snakes resemble the lizards, only a small portion being exuviated at a time. The eye of the sea-snake is so weak that, when the animal is taken from the water, all its attempts to strike prove ineffectual. The mouth is so closed by a development of the rostral plate, as to ordinarily prevent the entrance of water, though in some forms there are two small openings for the extrusion of the bifurcated tongue. The family possess poison of the most intense virulence, by which they obtain their food, which consists exclusively of fishes. These they seize and sting, the poison affecting the unfortunate animal so that it almost instantly dies, and in a relaxed condition, so that the serpent, in swallowing them, as it does, head first, has no inconvenience from the otherwise erect and rigid spines and barbs with which many pelagic fishes are armed. Though naturally shy, the sea-snake will, when attacked in its native element, dart at the intruder with all the vigor of the indignant terrestrial forms; but when drawn up in nets they are apparently helpless, the fishermen picking them up and throwing them back into the water with the most surprising unconcern. Many experiments have been made to keep the sea-snakes in aquaria, but they invariably die in a few days. All the forms are viviparous, the young, sometimes to the number of nine, being active swimmers from the first. The adult males may be easily distinguished from the females, as they have on each side of the tail an area which seems to be considerably swollen. The natural enemies of the sea-snakes are the eagle-rays and rapacious

sharks. Specimens of eight feet in length are common, while there is a single instance of one measuring twelve feet,—far too small, it will be seen, for the sea-serpent of the newspaper.

The genus *Platurus*, though found upon the high seas, has so many points of structure in common with the terrestrial, as well as at variance with the marine, serpents, that its position is that of a connecting form uniting the Elapidæ with the Hydrophidæ. The sub-cylindrical body, the smooth, imbricate scales, the well-developed ventral scutes, the divided sub-caudals, as well as the general physiognomy, — the cleft of the mouth being horizontal, while other sea-snakes have it turned up posteriorly — are characters which answer equally well for the members of the previous family. The scutellation of the head is quite regular; there are two pairs of frontals, seven labials, no loreal, and the nostril is lateral, a position unique in Hydrophidæ, and pointing to a partly terrestrial life, though positive information as to this habit has not been obtained. The poison fang is small and generally stands alone, though occasionally a small tooth can be found some little distance back. *Platurus scutatus* inhabits the Indian seas from southern India and China to New Zealand. It sometimes reaches a length of five feet. *P. fischeri* is a smaller form, having a geographical range of less extent, and is not found on the southern shores of Australia, though it extends further east, having been observed near the New Hebrides.

The genus *Aipysurus* is found around Australia and the neighboring islands. It has the body compressed, the cervical scales divided, the nostrils opening superiorly, and each surrounded by a nasal plate. The scales are of moderate size and may be either smooth or tuberculate; the ventral scutes are well developed and have a longitudinal median ridge; the sub-caudals are undivided. *A. anguillæformis* inhabits the Javan seas and reaches a length of two feet. The upper parts are brownish, ornamented with cross-bars of yellow, and the tail is terminated by a large shield-like scale. *A. lævis* has the terminal scale very large, and is of a uniform brown color, inhabiting the seas around New Caledonia and New Guinea, where it sometimes reaches the length of five feet. *Emydocephalus* inhabits the Australian seas and is characterized by having the ventral shields large, and with only a slight median ridge, the labials are reduced to six, and the imbricate scales are tuberculate. The tail ends in two large denticulated scales. The tortoise-headed ringed sea-snake, *Emydocephalus annulatus*, reaches a length of thirty inches. The head is covered with rounded plates, and the body is encircled by thirty-five black and as many more white rings. *E. tuberculatus*, the tortoise-headed brown sea-snake, is about the same size as its congener, but differs from it in having a longer head, larger and more tuberculated scales, and in being of a uniform purplish brown color, mottled with lighter spots along the sides. Of *Disteira* but a single specimen has been taken, the locality of which is unknown. It has the nasal shields separated by the frontals; and the ventral shields, though narrow, are distinct. *A. calyptus* is also an extremely rare ophidian, inhabiting the southwest Pacific; only two specimens are known. In length it measures about two feet.

Much different is the distribution and abundance of *Hydrophis*, a genus characterized by having the head of moderate length and well provided with shields, and the lower jaw without an anterior notch. There are enumerated of this genus as many as thirty-five species which are easily determined by reference to their general form and armament, the shape of the head, and the arrangement of the cervical plates.

Hydrophis cyanocincta, the form selected for illustrating the genus, is popularly

known as the chittul, and is characterized by having the scales faintly keeled, the ventrals broad, and the terminal scale of moderate size. Its color is greenish olive above, shading into yellow below, and decorated with from fifty to seventy-five black cross-bars, which in young specimens surround the body, though the adults generally have the ventral portions obsolete. It is one of the most common sea-snakes, being found south and east of Asia, and among the islands of the archipelago. It reaches a

FIG. 223. — *Hydrophis cyanocincta*, chittul, sea-snake.

length of six feet. *H. stokesii* is also a large form, an old female having been known to reach the length of sixty-one inches, and a height of four and a half. It is an abundant snake on the northern shores of Australia, though its more extended distribution is uncertain. The adults are of a uniform grayish color, shading into white below. *H. robusta* is a form which has caused considerable confusion among naturalists. It is large, ornamented with as many as thirty-five black rings, and is found in the waters at the south of India, as well as among the islands of the archipelago.

The eyed sea-snake is a beautiful animal inhabiting the Australian seas; it is known

to science as *H. ocellata*, the specific name being given because of the eye-like spots along the sides and ornamenting the back.

Of the family of Hydrophidæ no representative has a wider distribution than the yellow-bellied sea-snake, *Pelamis bicolor*. It not only inhabits the Indian Ocean, but has been captured on the coast of Madagascar, as well as on the west shores of America and as far south as New Zealand. On the Australian shores, numerous specimens are stranded during gales; the females, on dissection, have been found to contain as many as six young, these often of considerable size. In the Australian seas it is by far the most abundant representative of the family. It might be expected that a species so cosmopolitan would offer many varieties in minor points of structure and

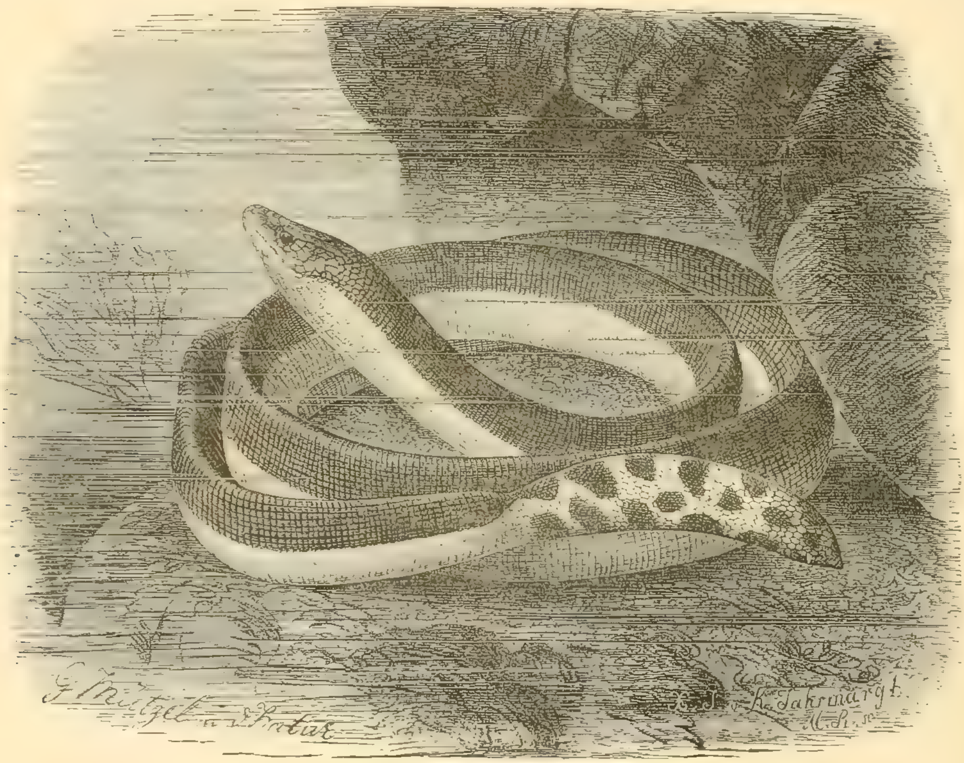


FIG. 224.—*Pelamis bicolor*, yellow-bellied sea-snake.

coloring, and this is the case. The first variety has the upper part of the head and body of a uniform black, and the belly brownish olive, the tail with black spots. These colors may be separated by a lateral line of yellow, which, in other varieties, may gain possession of the lower portion of the body, or infringe regularly or irregularly upon the black of the back. The length of three feet is not exceeded.

SUB-ORDER IV.—SOLENOGLYPHA.

The fourth division of ophidians has been subdivided into two groups, the basis for the subdivision being that, while the Old World representatives resemble those of

the western hemisphere in general form, habits, and in the effect of poison, they, as a rule, are different in not possessing a deep pit on the side of the head, between the eye and nostril, very characteristic of the American forms, or Bothrophera, and are hence distinguished as Abothrophera.

The fangs are the only teeth of the maxillaries of the Solenoglypha, which bones are so attached to the lachrymal and frontals as to allow considerable motion, that the fangs, except when about to be used, may lie against the jaw, where they are covered by two folds of tough membrane. Immediately behind the slender fangs, which are not only often broken off, but are regularly shed, are several incipient teeth, which, though only attached to the gum, are regularly pushed forward, and take their position as new fangs when the old ones are lost, becoming firmly attached to the maxillary bone. These fangs are perforated by a canal, which is quite evidently, on viewing the teeth in cross section, a mere fold of the anterior part, the lateral ridges being united together from near the base of the fang, where opens the venom duct, to a point a little above and in front of the apex, where it opens by a small slit. The venom gland, which is a modified salivary gland, varies greatly in size; in all cases, however, it contains a cavity where the poison is reserved until it is ready for use. Below and around this gland are a series of muscles, which, by voluntary contraction, can project the venom through the duct, down the canal of the tooth, and can throw it further, as a small jet, for some little distance. It has been often stated that the venom must, of necessity, be ejected by the pressure of the muscles, as the reptile strikes. This is not the case, however, as the serpent can, at will, control the flow of venom, and may even strike without poisoning the object of its anger; moreover, a thoroughly exasperated snake, when held by the neck, has been known to forcibly eject the venom, though no opportunity was given for striking. When, however, the animal is surprised in its native haunts, if no retreat is offered, it collects itself, so that the anterior part of the body can be straightened, and, on being further irritated, may strike with the mouth open and the fangs depressed, or it may erect the fangs and wound, or it may strike with the mouth closed, the fangs projecting as tusks on each side of the lower jaw. On the fangs entering the flesh, the snake, by throwing its head forward, makes a small cavity in front of the venom orifice, which receives the poison when the teeth are withdrawn. When small animals, intended for food, are thus wounded, they appear paralyzed, the snake watching them most intently, an action which has, to some people, substantialized the foolish notion of charming. As the venom is an active decomposing agent, it undoubtedly assists in digestion. It is an interesting fact that the members of Solenoglypha are viviparous.

The symptoms exhibited by persons who have been bitten by our more poisonous snakes seem to vary considerably; but it is probable that the poison, entering the blood, paralyzes the nerve centres, seriously affecting the function of respiration, and enfeebling the action of the heart. The venom, when taken into the alimentary tract, is harmless, as it is incapable of passing through the thick mucous walls, and its nature is more or less changed by the action of the digestive fluids. But through other tissues of the body, as the serous or muscular, it rapidly spreads; the blood thus affected being materially changed, and after death losing its natural coagulability.

The first thing to be done, on receiving a wound from a poisonous serpent, is to tightly tie a broad ligature between the part wounded and the heart, that the venom may be, only little by little, admitted into general circulation. The next thing is to enlarge the wound and suck from it the blood and poison. Spirits should be freely

given, that the weak action of the heart may be kept up, and finally, but as soon as possible, there should be injected directly into the wound a one per cent solution, in water, of potassa permanganas, a chemical antidote discovered by Dr. Lacerda, of Rio de Janeiro, and found to be very effective.

The first representative of the sub-order of which we treat is the *Actractaspis irregularis*, of southern Africa, a form the habits of which are little known. Though a small serpent, seldom exceeding two feet in length, it has the fangs developed in a most extraordinary degree, being so long as to reach back to the angle of the jaw. That this snake can strike as do other members of the sub-order is much doubted by

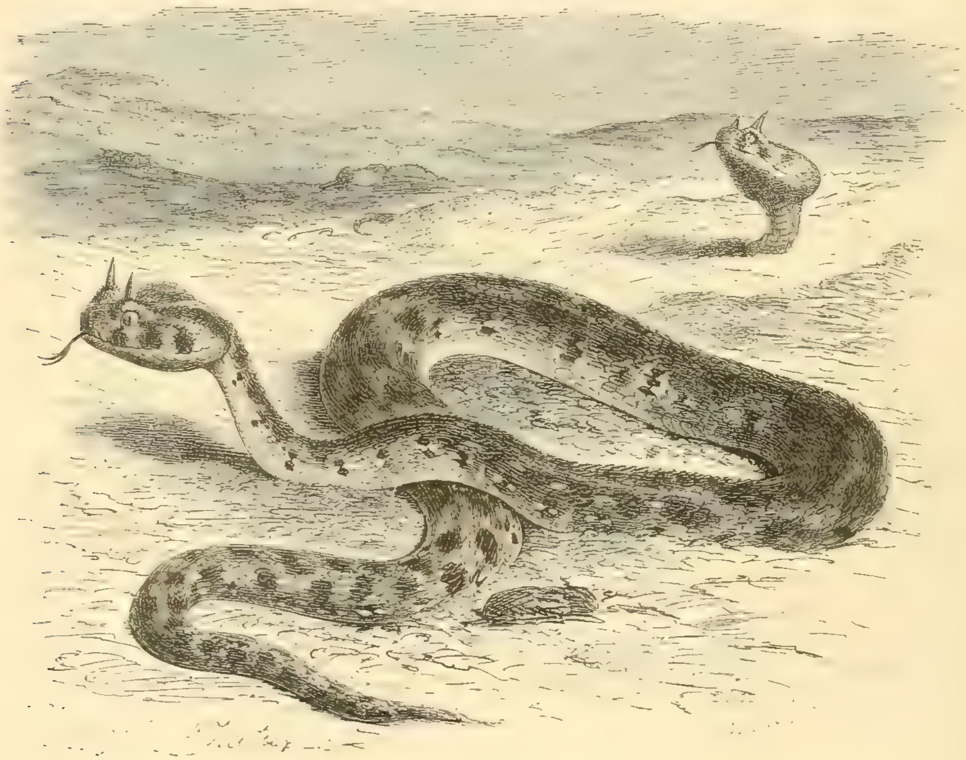


FIG. 225. — *Vipera cerastes*, horned-viper.

some, as the fangs seem to fill the mouth in such a way as to prevent their apices from being protruded.

The vipers have the body robust, the tail short and not prehensile; the head triangular and generally covered with scales, or at least incompletely shielded; the eye is of moderate size, and is provided with a vertical pupil, and in front of it there is no depression or pit so universally characteristic of the Bothrophera. The vipers, some of which grow to a considerable size, are inhabitants of Africa, and from their virulent nature have been known since time immemorial; the most common is the *Vipera cerastes*, or horned-viper. This animal, though not so poisonous as the cobra, is extremely dangerous. In its appearance it is a most repugnant animal, of a pale brownish-white color above, with spots and blotches of a darker shade. Over each

eye is a scaly spine or horn, which is supposed, by the ignorant natives, to be possessed of the most wonderful virtues. Though its home is in the hottest deserts of north Africa, where it lies half buried in the sand, awaiting the arrival of its prey, it can endure severe cold and prolonged hunger; the latter, however, might be expected from its habits. Specimens have been kept in confinement upwards of two years without taking any nourishment, though they sloughed their skins at regular intervals, showing that they were in a healthy condition. To this species has been attributed the questionable honor of producing the death of Cleopatra.

The asp, or *Vipera aspis*, has a wide distribution over Europe, extending north into Sweden, as the only boreal poisonous reptile. The bite of this ophidian is much

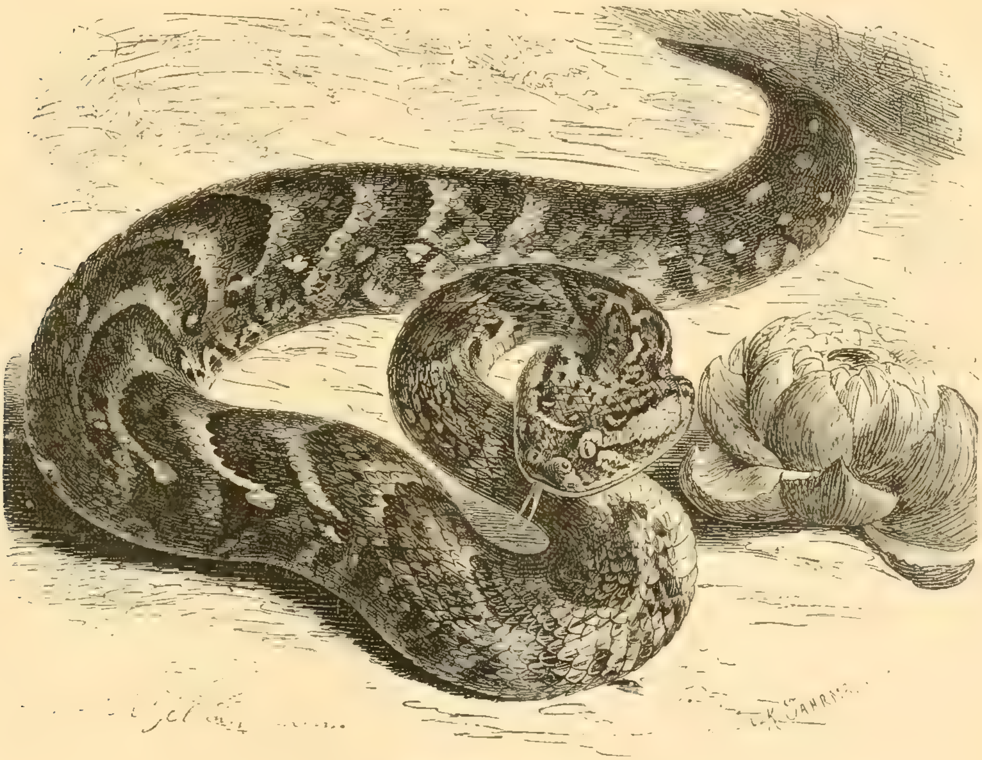


FIG. 226. — *Clotho arietans*, African puff-adder.

dreaded, for, though it only rarely produces death, it is very painful, often inducing the victim to amputate the affected part rather than endure the pain or run the risk of possible death. The viper or adder, *Pelias verus*, is the only venomous reptile known to inhabit England, where, as has been already stated, it is often mistaken for the grass-snake, which, in turn, is not infrequently mistaken for the adder. They are easily distinguished, however, as the poisonous reptile has a zig-zag chain of dark spots running along the back, which are not present in the innocuous form. The ground color of the viper is, moreover, generally of a greenish-olive or brown, though specimens of a yellow, a brick-red, or a black color have been captured. To this species, as is the case with many other poisonous reptiles, the habit of swallowing or partially swallow-

ing the young, in the apprehension of danger, has been attributed. Though the people who are willing to swear that this is an ordinary occurrence are numerous, they are, nevertheless, often uneducated; the fact that not a single naturalist of good standing has ever observed the trait, though many have been their endeavors, seems to cast considerable shade on this case of parental oversight. The poison of this animal must be of a very strong nature, for though it is only in the minutest quantity when compared with that of such animals as the rattle-snake, it is capable of producing the most severe symptoms, which sometimes last for days. During the cold season the adders, like the American copper-heads, congregate together, often entwining themselves into a ball of the most repulsive appearance.

The African puff-adder, *Clotho* or *Echidra arietans*, has received its popular name because of its habit of swelling or puffing itself up when irritated. It is both the largest and the most poisonous reptile of South Africa, not infrequently reaching a length of over four feet, and while other poisonous snakes are sufficiently active to endeavor to escape on seeing an intruder, the puff-adder is so consummately lazy that, rather than move or make itself known, it will remain, half buried in the hot sand, with its sullen eyes fixed upon the unsuspecting traveler with a most freezing glare, and if irritated in the slightest way, it starts up a hissing, which is followed, if the animal is further approached, by a most deadly attack. It is with the poison of this animal that the Bushmen arm their most effective arrows. In collecting these serpents they are said to walk up to the sullen animals, and before the snakes have fairly made up their mind to strike, plant the bare foot upon the neck and sever the head with a small knife. The color of the reptile is brown, variously ornamented with spots of gray or white. *Clotho nasicornis* is also an inhabitant of Africa, where it has received the name of river-jack. The male is peculiar in having a spine, protected by scales, projecting from the upper side of the nose, between the nostrils. *H. cornuta*, or the plumed-adder, as it is called, derives its name from the peculiar plume-like structures which appear over each eye. Though short and stout, it is very beautifully ornamented, the body being marbled with chestnut, and punctate with numerous small dots ; along each side of the vertebral line are two rows of dark blotches.

Of the Indian vipers there are but two kinds, *Daboia russellii* has the nostrils very large, laterally placed, and surrounded by three shields. The head is covered with scales, those of the sides as well as those of the body being keeled. The general color is brown, with three rows of large white-edged rings, of which those of the middle of the body are largest; the lower side is yellow, and in some cases marbled with brown. The ticpolonga, as this species is called by the natives of Ceylon, inhabits not only that island, but also India, as far as the Himmalehs. It is a most common terrestrial reptile, and is much dreaded, being nocturnal in its habits. It is sometimes fifty inches in length, feeds on small mammals, and has been named by the Europeans, because of its venomous nature, the cobra monil.

The other Indian viper, *Echis carinata* is structurally different from the previous species, in that the sub-caudals are simple, and the nostrils are small, and situate in a large, posteriorly divided nasal. The small keeled scales of the head are imbricate, two rows of which are between the eye and the labials. It differs chiefly from its African congener in having a fewer number of ventral shields. *E. carinata* is common in many parts of India. It never exceeds a length of twenty inches. Being such a small snake, its bite is not known to have ever proved fatal, though some authors speak of it as a most virulent form, requiring a double dose of medicine to

counteract the effects of its poison. *Trimeresurus* (including *Berias*, and *Megæra*), embraces those vipers which, from their green color and prehensile tails, are fitted for an arboreal life. They are provided, as are the remaining genera of the sub-order, with a small pit in front of the eye, which indicates the lachrymal fossa of the American Crotalidæ, of which they are the Old World representatives. The members of the present genus are naturally of a sluggish disposition, remaining for hours at a time resting along some branch, which they resemble so closely in color as to attract no attention until they have made their presence known, either by a warning hiss, or by immediately biting. Though their ordinary small size generally prevents the bite from proving dangerous, some of the larger specimens may inflict wounds which result in death. Ordinarily, however, the symptoms, though severe, are confined to nausea and fever, seldom enduring for any long period. The pain and swelling having subsided, the neighborhood of the wound becomes black and mortifies, and is finally thrown off, after which the patient soon recovers his former strength. The animals ordinarily feed on birds and mammals; other ophidians as well as lizards being rejected.

Trimeresurus trigonocephalus is a good representative of the genus. It is an inhabitant of Ceylon, where it leads an arboreal life, and reaches, when adult, the length of thirty-one inches, of which the prehensile tail is about one sixth. The color is green, with a network of black stripes on the head, which is produced backwards as a median dorsal line, sending alternate lateral branches to the sides. The lower surface is pale green, marbled with blackish posteriorly.

Peltopelor has but a single representative, *P. macrolepis*, an animal inhabiting the Anamallay mountains, and reaching a length of twenty-one inches. It has a large pit in the loreal region, the body with twelve series of large, keeled scales, and the head with small, imbricate scales. Its color is of a uniform green, brighter below, with lateral lines of bright yellow.

Calloselasma is also represented by a single species. It has smooth scales, the head protected above by cervical plates of the normal number; and the tail, which is not prehensile, terminated by a long spine-like scale. *C. rhodostoma* inhabits Java and Siam. Though only attaining a length of three feet, a single specimen has been known to cause the death of two men in five minutes.

Hypnale nepa, the only representative of its genus, is found in southern India and Ceylon, where it is known as the carawala and is greatly dreaded, though its poison does not prove fatal until it has been in the system for several days, there being therefore every hope, provided the proper remedies are only applied in time. Like the other viperine snakes, it is viviparous, the young, five inches in length, having been dissected from the female. The animal has the shields of the snout scale-like, while the other cervical shields are normal.

We now come to those Solenoglyphs which are distinctively New World, and are included under the head Bothrophera, the several genera of which have not only the peculiarities of structure already mentioned in the introductory remarks to the sub-order, but also the following: The general form of the body is stout, and the large, flat, triangular head well separated from the body, which latter is either terminated by a series of so-called rattles, or may be of the ordinary cylindrical form; the pupil is elliptical, its longer axis being vertical; between the eye and the nostril is a deep pit, which characterizes the group, though some ophidians of the eastern hemisphere have a somewhat similar depression. The venom glands are behind the eye, lying

along the sides of the skull, and open into the tubular fangs. The scales of the body are keeled and the anal scale is entire.

The introductory genus is *Ancistrodon.* It is represented north of Mexico by two species which are alike in having the sub-triangular head distinct from the neck, and the tail short and tapering to a point. There are both frontals and parietals, and the loreal may be present or absent; the scales of the body are arranged in twenty-three or twenty-five rows, and the pits at the side of the face, are well represented.

The so-called highland-moccasin, *A. atrofuscus,* has not been collected since the time of its original description. It and *A. piscivorus* are undoubtedly the same species.

FIG. 227. — *Ancistrodon contortrix*, copperhead.

The copperhead, *A. contortrix*, has an extended geographical range, being found from New England to Florida, and from the Atlantic to the Mississippi, and is popularly known as the copperhead, because of its dark bronze-colored head. Though it is occasionally found in meadows, in the neighborhood of water, searching for mice and small birds, its proper home is in the wild mountainous districts where the pregnant females are known to gather in large numbers and entwine themselves, as do the European adders, into a huge mass of living venom, presenting to an intruder a most formidable appearance. The young, which, like others of the sub-order, are brought forth alive and active, show from the first a most irascible temper, when only a few hours old striking right and left, apparently trying to test the power of their sharp and delicate fangs. The number born of one female is not known to exceed seven. The young probably hibernate with their parents.

The copperhead is of a bronze hazel or light reddish brown above, with a series of transverse, dark brown bands which enlarge on the flanks into blotches. The lower surface is of a flesh color and spotted, as is much of the back, with minute dots of dark brown. Along each flank is a row of dark spots alternating with and between the bifurcations of the dorsal bands. There is a loreal plate, and the scales are dis-

FIG. 228. — *Ancistrodon piscivorus*, water-moccasin.

posed in twenty-three rows. These last characters at once separate the present form from the succeeding, which has no loreal, and the scales arranged in twenty-five rows.

The water-moccasin, *A. piscivorus*, is an animal dreaded by the travelers of the south even more than is the rattle-snake. While the latter only takes the defensive on being irritated, and ordinarily makes its presence known by sounding its alarm, the

moccasin strikes at every object that displeases it, and will even raise its head and spitefully strike at objects some distance away. In confinement, harmless snakes have shown the greatest apprehensions on being placed in company with a moccasin, which, nevertheless, they greatly exceeded in size. The moccasin, like the cobra of India, seems well aware of the power which it possesses, for while the harmless snakes above spoken of were soon attacked and poisoned, on the introduction of moccasins, an understanding was obtained, and mutual respect resulted in perfect harmony. In out-door life, the moccasin, which has for its habitat the southern states from the Carolinas to Texas, is always found in the water or its immediate neighborhood. The reptile is often seen resting upon the low branches of some overhanging

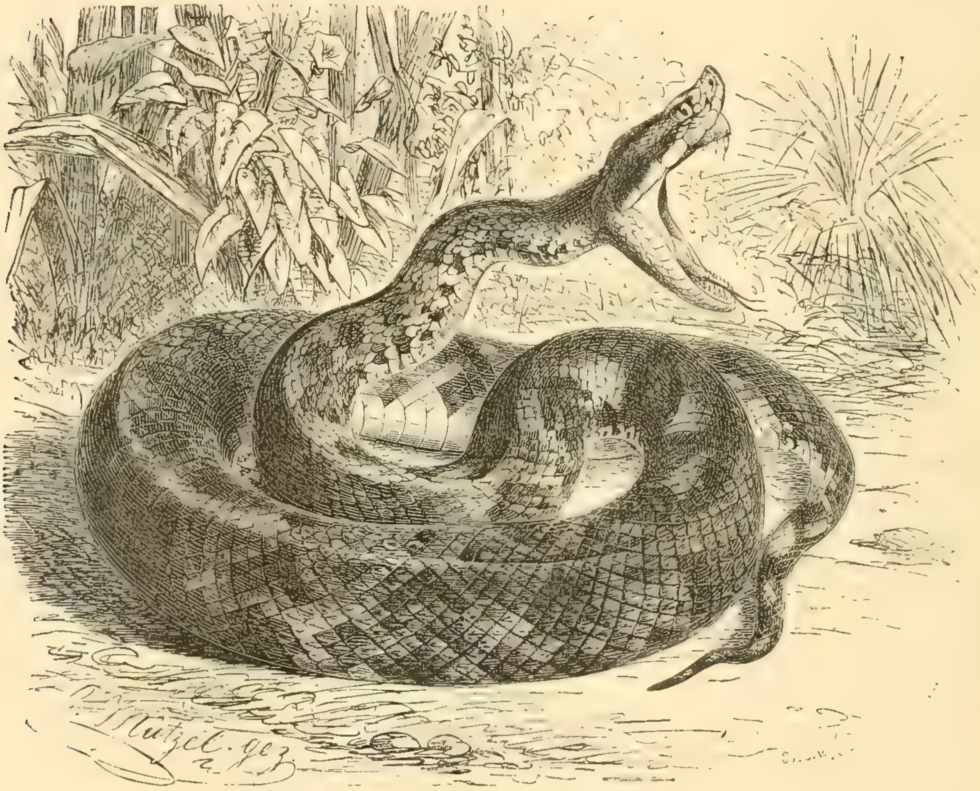


FIG. 229. — *Trigonocephalus lanceolatus*, fer-de-lance.

tree, where it can at once bask in the sun and watch for its prey of fish, tadpoles, frogs and the like, which it has no difficulty in catching, as it is a most active swimmer. The coloring of this species is of an olive shade above, with about a dozen transverse black bars; below, brownish yellow, mottled with dark blotches. It can most easily be distinguished from the preceding species by comparing the cervical plates, and counting the longitudinal rows of scales. The variety *pugnax* is based upon a narrow and crowded second labial; it inhabits Texas. Specimens of the moccasin seldom reach four feet in length.

The genus *Trigonocephalus* includes the most venomous animal of the western hemisphere, the celebrated fer-de-lance, *T. lanceolatus*, of Brazil. This animal being

of a most aggressive disposition, attacking without giving warning, actually abounding in its habitat, growing to a large size, and being of remarkable fecundity, probably causes the death of more laborers in the sugar plantations of South America than any other agent. Its venom is not spent in defence alone, but the fer-de lance being a most voracious animal, it is of value in securing the rats and other small rodents which would, were it not for this serpent, as well as several others, soon overrun and destroy the cultivated districts.

Under the generic name *Caudisona* appear those forms which resemble the true Crotali, in that they are provided with the terminal rattle, but they show their intermediate character in that the plates of the head are much like those of *Ancistrodon.* The head is large and triangular and well shielded with frontal and parietal plates, the deep pit is present, but the rattles are but poorly developed and few in number, being only capable of giving a feeble alarm.

Caudisona tergemina, the black rattle-snake or massasauga, is found in Ohio and Michigan, and southward to Mississippi; it has the scales in twenty-three or twenty-five rows, a large pre-orbital, and a small and sub-triangular loreal. In coloring it is light ashy brown or black on the back, depending on the exposure to which the animal has been subjected; those having lived in dry open localities seem to be bleached out. The back is ornamented with seven rows of irregular spots. This animal is often found in the burrows of the prairie-dog, *Cynomys ludovicianus*. *C. edwardsii* is a rare and a beautiful species inhabiting northern Mexico, Texas, and Arizona. The scales are in twenty-three rows, the two outer rows being smooth. The general color is yellowish brown with several series of spots, the dorsal series numbering about forty-two. The belly is light yellowish mottled with brown. *C. miliria* is a very abundant form in the south, where it has received the name of ground rattle-snake, being frequently found among dry leaves and in tangled grass, searching for small field-mice. As it seldom gives any warning before taking the aggressive, it is very much dreaded, especially by the common people, who regard it as even more dangerous than *Crotalus horridus*, but experiments show that its bite is not as virulent; a cat which was severely wounded, recovered at the end of a couple of days. Though the ground rattle-snake has sufficient venom to kill the animals on which it preys, as the towhee buntings, and field-mice, it has not, being but a small reptile, a sufficient quantity to dangerously affect the larger animals. It has the scales arranged in twenty-one or twenty-three rows, all but the outer keeled, and the labials numbering from ten to twelve, the infralabials eight to thirteen. The coloring is generally dark, of an ashy-brown shade, with a dorsal series of from thirty to forty irregular, band-like, black spots with light edges, which become divided towards the tail. Along each flank and also along the belly are three series of smaller spots alternately arranged. The greater number of specimens have a dorsal line of a reddish color. The habitat is along the southern states and Mexico. *C. rava* inhabits the table-lands of Mexico, and is allied to the previous species. It is of a yellowish color ornamented with from twenty-six to thirty deep brown dorsal and an equal number of alternately arranged lateral spots. The head is pale and immaculate, save a very minute punctulation. The species is at present quite rare in museums.

The genus *Crotalus* has the parietal shields scale-like and the frontals either divided or absent; the tail is terminated by a well developed organ, popularly called the rattle. Of this genus there are several species, which number some naturalists have augmented by including the members of the previous *Caudisona*. As now restricted

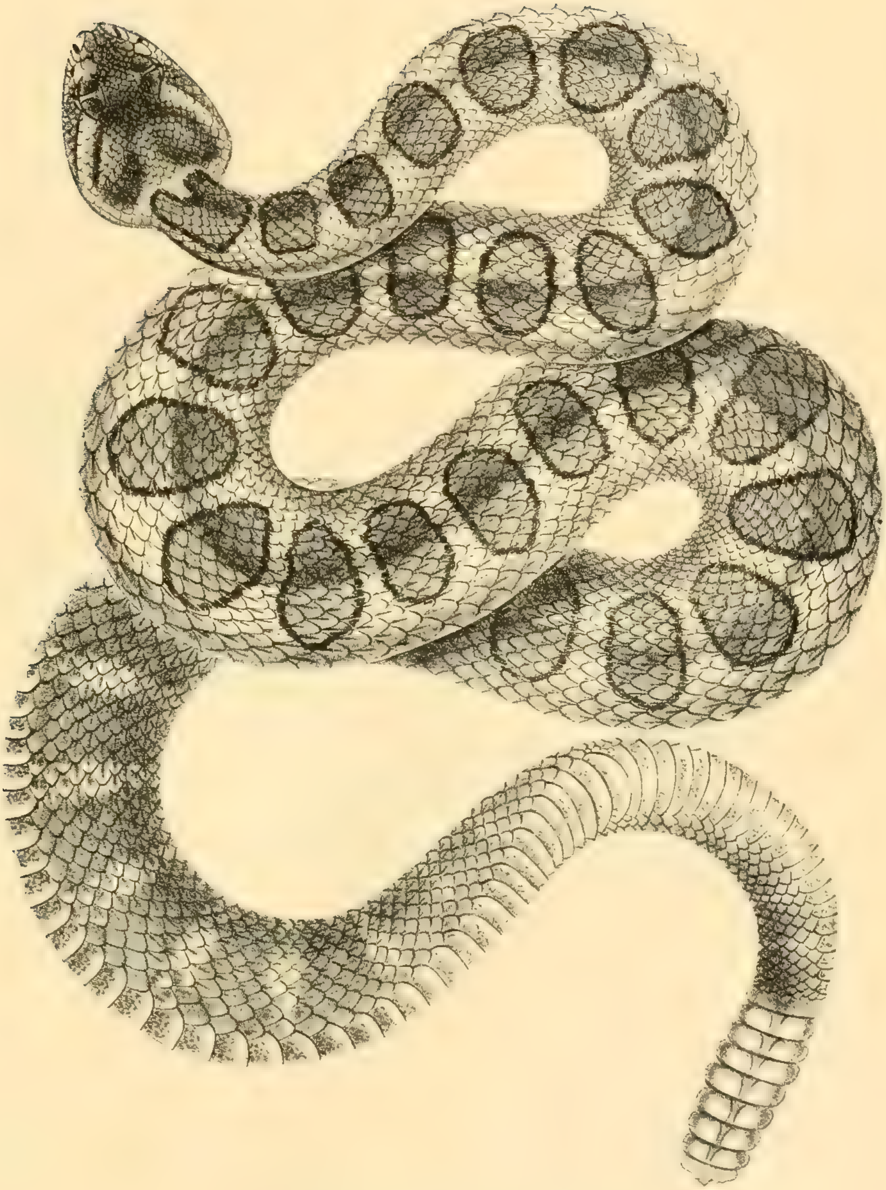
there are about fifteen species, many of which present several local varieties. Although the Australian *Acanthophis* and many members of the genus *Typhlops* have the tail terminated by variously formed spines, the appendage peculiar to *Crotalus* is by far the most interesting, as it is by far the strangest development. As to its use, many have been the theories; some claim that, as the sound resembles that produced by several insects, it is a lure for insectivorous birds, but observation has shown that, while hunting, the snake ordinarily preserves quiet; it is moreover seldom that birds are found, on dissection, to be in the stomach. Equally weak seems the explanation that the sound produced by the rattle so terrifies the smaller animals on which the snake feeds, as to render them helpless and thus easily captured. To many it might seem probable that it is a special organ designed for bringing the sexes together in the mating season, an end which is often gained by other and numerous means, but, while mating, the rattle, though used, is not vibrated with as much energy as it is when the reptile is irritated, and it is here that we find the probable use of the organ. Though ordinarily perfectly able to defend itself, the rattle-snake is, after having repeatedly drawn from its supply of poison, for some little time comparatively helpless, and being rather slow, as well as having a sullen disposition, it would, were not some provision made, suffer from its temporary helplessness. This is prevented, however, by the rattle, which the snake, on being surprised, uses as an alarm, making its presence known, the reptile thus avoiding the undue waste of poison, which to it is an essential means of protection.

The rattle, a most common cabinet curiosity, is made up of a series of depressed horny rings, each consisting of a posterior tongue-shaped portion, which is held in the hollow, cup-like, anterior portion of its succeeding fellow by a terminal knob, the so-called 'button.' It will thus be seen that if a portion of the rattle is broken off, a 'button' will always remain. As such an accident is not infrequent, and since several new joints may be added during a season, the number of rings can in no way indicate the age of their possessor, though we must give up all hope of this fact ever being comprehended by the ordinary local reporter.

The habit of rapidly vibrating the tail, when excited, is possessed by many ophidians, and when it is done while the reptile is in dry leaves, a noise is produced so resembling the alarm of the rattle as to even deceive an expert. This habit of many harmless forms has often resulted in their death, they being first mistaken for adult rattlers, though, when killed, the excited hero, not finding the terminal appendage, and not willing to allow the mistake, maintains it is a young rattler, an assumption often apparently substantiated by an inspection of the tail, which is often tipped in many innocuous ophidians by a smooth horny scale.

Crotalus durissus is the introductory species, and is found from Mexico to Brazil. It has often been confused with *C. horridus*, but is at once distinguished from that animal in that it has the scales arranged in twenty-nine or thirty-one rows, and the dorsal markings more regular and taking on a lozen-shaped form. The keels of the scales are very large and swollen, though, as in *C. horridus*, they do not arm the outer row of scales, which are large, smooth, and broad. The general color is yellowish brown, ornamented along the back by a series of sub-diamond-shaped brown spots with light centres and yellow borders, and which, as they continue to the flanks, enclose rhombs of the general ground color. The yellowish belly is clouded with darker shades.

Crotalus molossus is a native of New Mexico and Arizona, and is characterized



Crotalus lucifer, Oregon rattle-snake.

by having the nasal plates divided; four prefrontals; eighteen labials; seventeen infralabials, and the scales in twenty-four rows. The body is yellowish, strongly marked with a dorsal series of rhombs, similar to those of *C. adamanteus.* An allied species collected at Fort Whipple, measuring thirty-one inches in length, contained an adult blue-bird, *Sialia mexicana.* They are reported from the San Francisco mountains at an elevation of 10,000 feet, and inhabit dry rocky ground. *C. confluentus*, the prairie rattle-snake, is very abundant along the Missouri River and its tributaries from Nebraska to the Rocky Mountains. During the hot season they retire to the dry cañons, where they hide among the willows, being extremely sluggish and stupid, and possibly partially blind, as the cuticle, though cleaving from the body and eyes, is not as yet shed. The head is sub-triangular, and the plates irregular, angulated, imbri-

FIG. 230. — *Crotalus durissus*, rattle-snake.

cated, and not infrequently tuberculated. The labials are from fourteen to eighteen above and below, and the scales of the body are arranged in from twenty-five to twenty-nine rows. Along the back there are between forty and fifty brown spots margined with narrow white lines. *C. polystictus*, inhabiting the table-lands of Mexico, seldom reaches the length of two feet. There are two nasals, two loreals, fourteen labials, and thirteen infralabials; and, of the twenty-seven rows of scales, all are keeled excepting the lower two. Along the back is a median yellowish stripe bordered by lines of grayish brown, and ornamented by a series of seven brownish black spots.

C. lucifer, the western black rattle-snake, was brought to the light of science in 1852, by the description of Baird and Girard from specimens captured by members of the exploring party under Captain Chas. Wilkes in California and Oregon. The

general color is reddish brown above, deeper along the back, and yellow beneath, though a specimen that had just shed its skin, captured on the Columbia River, had the ground color pure white, with sea-green patches on the back. Ordinarily, the patches are in a series of sub-circular white rings, lined internally with a narrow black line. The internasals are subdivided, and separated from the nasals by a row of small scales. The rostral plate is small and pointed above, and pentagonal in form, and there are from thirteen to sixteen labials. The scales of the body are arranged in about twenty-five rows. Rattle-snakes are most abundant south of the Columbia River; west of the Cascade Range they are very rare. At the Dalles the present species has been so abundant as to be very annoying, specimens sometimes entering

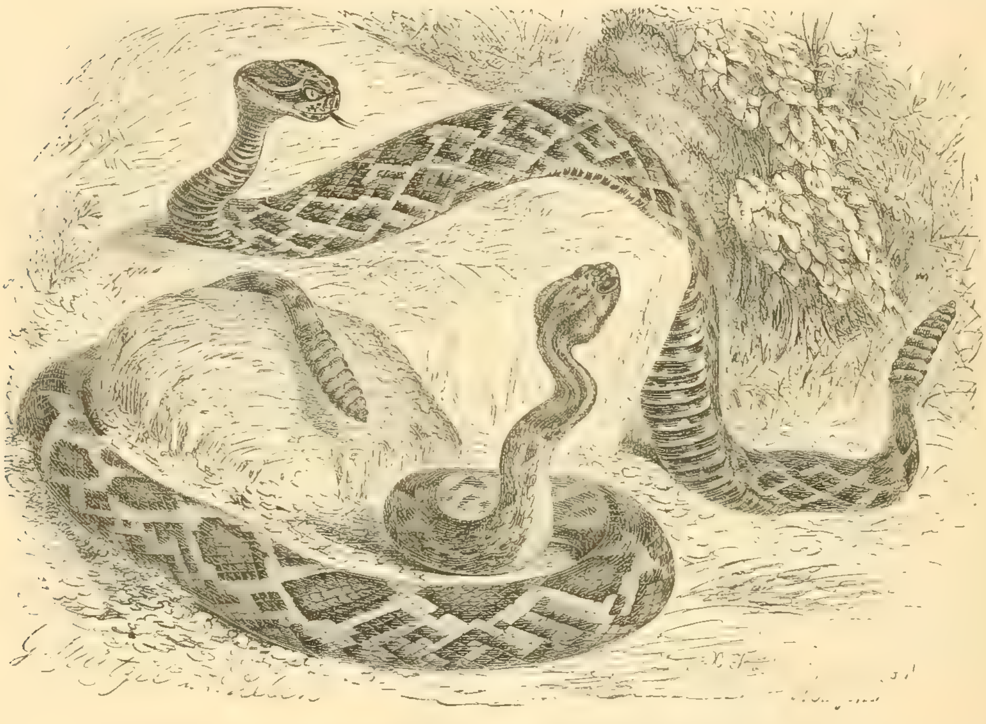


FIG. 231. — *Crotalus adamanteus*, diamond-rattler, and *C. horridus*, banded rattle-snake.

human dwellings, though of late, since the introduction of hogs, their numbers have considerably decreased. The Indians, it is said, use the tail of this rattle-snake to produce abortion.

Crotalus adamanteus is distinguished by having the parietals and frontals scale-like, the nasal divided, the loreals generally two, and the scales, the keels of which are not tubercular, arranged in twenty-seven or twenty-nine rows. The color is yellowish brown, and the back is ornamented by a series of about thirty distinct, diamond-shaped spots, which are dark brown in color, with a lighter centre, and margined with yellow; on the tail these spots pass into transverse bands. This species is an inhabitant of the southern states, and its varieties extend to California and into Mexico. In its habits the diamond-rattler prefers the damp and shady places in the neighborhood of water, though there is no evidence that it follows its prey into that

element. From this preference the reptile is commonly known as the water-rattler in some portions of the south, though the name diamond-rattler, given because of the diamond-shaped markings of the back, is more general. Holbrook, in speaking of it, says: "A more disgusting or terrific animal cannot be imagined than this; its dusky color, bloated body, and sinister eyes of a sparkling gray and yellow, with the projecting orbital plates, combine to form an expression of sullen ferocity unsurpassed in the brute creation."

The most abundant species east of the Mississippi is *C. horridus*, popularly known as the banded rattle-snake. It has a very general distribution from Maine to Texas, being in some localities quite common, though the universal war waged against the species has greatly reduced its numbers. At one time it was very abundant on a low range of hills in eastern Massachusetts, where it was possible to obtain several specimens in a short time, but it is now extremely rare, and is only met with on the most unusual occasions. Further south, in some localities, the animal is still abundant, though never occurring in such numbers as to, in any way, hinder — as a related form of the west does, — the local sportsman from following his bent. It is naturally sluggish, and will often remain perfectly motionless while an unsuspecting intruder passes within a few feet, but the instant the reptile is perceived, it ordinarily coils itself for an attack, and may remain thus on the defensive, ready to strike at whatever may displease him, but never following the object of his rage; after a short time he may uncoil, and, as Holbrook says, "slowly retreat like an unconquered enemy, sure of his strength, but not choosing further combat." That the reptile cannot strike unless coiled, is a mistaken notion, for although this position is ordinarily chosen, — the animal thereby having a greater reach, — when angry and confined it will strike right and left, coiled or uncoiled.

The rattler feeds on small rabbits, rats, and squirrels, which latter Dr. Bachman, the intimate friend of Audubon, has observed the snakes to watch as they sported among the branches of a large tree; undoubtedly waiting to pounce on some unfortunate one that might descend for a fallen nut or acorn, or possibly to search for water. The old belief that serpents 'charm' is now obsolete, though not extinct. That such a belief should once have been current is not surprising, since birds are often seen to flutter around a marauding snake, but really more from maternal solicitude and friendly sympathy on the part of the birds than from any reptilian power of fascination. The instinctive, and sometimes paralyzing horror which seizes on one when he knows he is the object of some frightful monster's fixed gaze may also be adduced as a cause for a belief so general until within a few years.

The parietals and frontals are scale-like; the nasal plate divided; scales in twenty-three or twenty-five rows, of which all but the lateral are strongly keeled; the labials are numerous, there being along the upper border of the mouth from twelve to sixteen on each side, and eighteen along the lower jaw. There is a dorsal series of more or less irregular and imperfect transverse bands; the general coloration is variable, some specimens have the ground of a bright yellow color, while others are almost black. The length of four feet is seldom reached, though a specimen fifty-four inches long has been captured. As many as twenty-three rings in good condition have been known to compose the rattle.

Crotalus enyo resembles *C. molossus* in general coloration, and is a very beautiful animal. It can easily be distinguished from the species named, however, as it has a peculiar scutellated muzzle, and there are only twenty-three rows of scales, *molossus*

having twenty-nine. It is of a yellow color above, with the ordinary series of small transverse rhombs, which send lateral prolongations to the sides of the body. It inhabits Lower California.

Crotalus tigris is a form which has the nasal plate divided, and the keeled scales disposed in as many rows as those of *C. cerastes.* The head is depressed, and being narrow behind, and the nose broad and obtuse, it is quite quadrangular in outline. The animal is of a yellowish ash above, with small clustered blotches anteriorly, which develop into brown bands further back. *C. cerastes* inhabits California, Arizona, and Mexico, preferring localities where there is absolutely no trace of vegetation, such as are those of the southwest deserts, where it is extremely abundant. Its chief structural peculiarity is the pair of horns surmounting the head, and giving the animal the appearance of the horned-viper, *Vipera cerastes*, of Africa, which animal it further resembles in being very sluggish, and in its choice of locality. The New Mexicans have named this animal the 'side-winder,' because of the slightly lateral motion which they have in passing forwards.

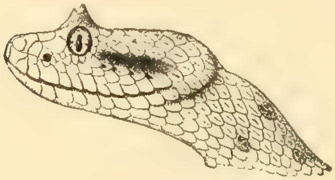


FIG. 232. — Head of *Crotalus cerastes*, horned-rattler.

The next member with which we deal is *C. pyrrhus* which has the head obtuse and rounded, the labials fourteen, and the loreals four. It is a most highly colored animal, being of a bright salmon red, with transverse bars of a deeper shade, which are broadest along the back, and lateral series of yellow blotches. A specimen captured in Arizona during a hasty retreat from hostile Indians, by members of the 'Wheeler Survey,' attracted considerable attention as a 'red rattle-snake.' *C. mitchellii* has many points in common with the red-rattler, though it has but one loreal, and the small upright nasal is separated from the rostral and labials by a series of small scales. The general color is grayish yellow, with indistinct quadrate markings along the back, which at the tail are reduced to bands. The scales are in twenty-five rows. This animal, the last of the genus, has been only found in Lower California.

The last and highest member of the family Crotalidæ is the *Aploaspis lepida*, a form inhabiting western Texas, and first described in 1861.

ORDER II. — PYTHONOMORPHA.

The members of the order which we now treat lived at a time when the American continent was considerably lower than it now is. New Jersey and Delaware, as well as a greater portion of the southern states, were then under water. The Mexican Gulf extended as far north as the Ohio River, and the Rocky Mountains, in some places 10,000 feet lower than they now are, appeared as a range separated from the valley of the Mississippi by a broad expanse of salt water which teemed with animal life; the immense chalk-like deposits of the protozoans suggesting the name of the period, the cretaceous. It was during this period, when the sea was somewhat warmer than at present, that gigantic reptiles, in their general form and movements resembling huge eels, ploughed through the water by means of their four paddles and propeller-like tail, in search of fishes and other marine life, much in the same manner as does the sea-snake of to-day.

The Pythonomorphs, though occasionally found in European deposits, are best known from American specimens, which are abundantly found in the limestone rocks of Kansas and the cretaceous deposits of New Jersey and Alabama. A careful examination of the fragments has shown that the animals were greatly elongate; the head large, flat, and conical; the eyes, though placed at the sides of the head, being directed more or less upward; and the limbs represented by two pairs of broad paddles, firmly united with the body. In several particulars these ancient forms resemble the serpents. The teeth were disposed in four rows along the upper jaw, though differently arranged, for although the palatine and maxillary bones were armed, the premaxillary teeth appeared in two rows instead of one. They were used only as organs for seizing the prey, which was swallowed whole, without mastication. The lower jaw had not the bones connecting it with the head movably articulated and allowing displacement, though the rami were united in front by the elastic ligament so characteristic of the previous order. The distention of the mouth was provided for, however, by a special structure only represented in a few serpents and in the young of some birds, like the heron. This consisted in the jaws being provided, midway

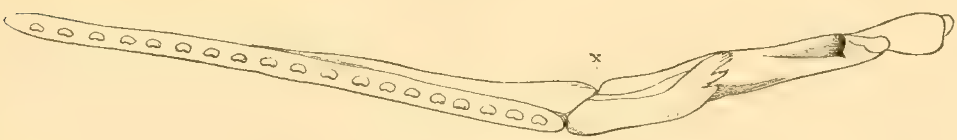


FIG. 233. — Jaw of *Clidastes*; *x*, sphenial articulation.

of their length, with a hinge, the splenial articulation, which enabled the rami to bow out and allow the most bulky prey to gain easy access to the large and spacious gullet.

By reference to the figure of *Clidastes*, it will be seen that the pectoral arch consisted of only a scapula and coracoid, and that the pelvic arch had no rigid sacrum, and was but loosely united on the middle line below. The ilia were long, and not immediately in contact with the vertebral column. The pubic and ischiatic bones were small and free. The pes and manus, and both limbs, were small in proportion to the size of the animal, and of a less robust type than in any other order of marine Reptilia.

The quadrate bones movably attached to the sides of the skull, the simple articulations of the ribs, and the free vertebræ of the sacral region, are points which unite Pythonomorpha with Ophidia and Lacertilia. The general structure of the posterior portion of the lower jaw is like that of lizards, while the chevron bones, protecting the sub-caudal continuation of the aorta, are not ophidian. The teeth, being without true roots, are not like those of Lacertilia, nor are they identical with those of Ophidia. It will be seen that the animals require an intermediate position between the previous order and the one succeeding, the Lacertilia. With the other orders, except the Chelonia, which they resemble in having the quadrate bone partly enclosing the auditory meatus, and a few points resembling the Plesiosaurs, they have little or no affinity.

The genus *Clidastes* is represented by about a dozen species once inhabiting the

coasts of New Jersey and Alabama, as well as the "Western Sea." It contains the most elongate forms of the order, though they do not reach such a size as do some of the *Liodons.* The quadrate bone gives evidence that there was considerable lateral flexure of the mandibular rami; and that the animals were strong and muscular is shown by the striations and sculptures still appearing on many of the bones. That the vertebral column might not be dislocated by the animal's powerful contortions, the vertebræ are provided with an extra pair of articular processes which are very characteristic. The largest representative is *C. cineriarum*, from the Kansas strata, and reaches a length of forty feet. *C. tortor* was a lithe and active animal, with numerous knife-like teeth, and probably fed on fish. *C. pumilus* is remarkable for its small size, being only about twelve feet in length. It was probably not infrequently the unfortunate prey of some of the larger cretaceous sharks.

The genus *Platecarpus* is also represented by about a dozen species which resemble *Clidastes* in the form of the humerus, though the vertebral articulations are like those of *Liodon.* The muzzle is considerably shorter than in the previous genus, from which the animals also differ in having the chevron-bones free from the vertebral centra. The teeth are very characteristic, being neither compressed like *Liodon*, nor angularly faceted as in *Mosasaurus* but are curved and, in section, sub-circular. Such specimens as have been discovered have been of medium size.

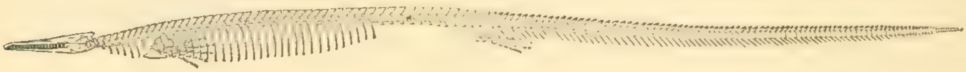


FIG. 234. — Skeleton of *Clidastes*, restored.

Mosasaurus has been abundantly found in the greensand of New Jersey, and other cretaceous localities further south. It differed from the two previous genera in having the flippers more pedunculate, the humerus and femur being more slender, and in having the teeth provided with facets. The chevron-bones are in part coössified, and the arches of the vertebral column interlock, presenting in rudiment, the articular processes of *Clidastes.* The representatives of this genus, of which there were in Europe two, and in America, where the animals were much more abundant, nearly a dozen species were, like other Pythonomorphs, long and slender, and with a flattened, pointed head. The food, which was captured alive, was quickly swallowed, passing, on its way to the loose pouch-like gullet, between the expanded branches of the lower jaw. *M. maximus* was the largest species, and sometimes reached a length of eighty feet.

The genus *Liodon* has the teeth compressed, lenticular in sectional outline, and formed for cutting. The vertebræ have not the strong articular processes of *Clidastes* and the humerus is small and narrow. The typical species of the genus was described by Owen from remains found in the English chalk, and is extremely rare. In America the forms abounded during the chalk period and were the giants of the order. *L. proriger*, of the Kansas beds, measured seventy-five feet in length, and was provided with a long projecting muzzle, a development possibly used as a ram when fighting. *L. dyspelor* was probably the largest of known reptiles, considerably exceeding the *Mosasaurus maximus* in size. The source of the food supply of such monsters may well excite our curiosity, as their magnitude does our surprise.

ORDER III. — LACERTILIA.

To this order belong the lizards, which may be defined as all now existing reptiles having a pectoral girdle and sternum, and, as a rule, four limbs. A tympanic cavity is usually present, and the eyes, with a few exceptions only, are provided with lids. The bones of the jaws and head do not allow that expansibility generally characteristic of snakes, and a still further departure is made from this group in that the lizards are provided with a urinary bladder.

The lizards are generally of an elongated form, and snake-like, some carrying the resemblance still further by having the limbs reduced to rudiments, or externally entirely absent. The limbs, when present, are seldom sufficiently strong to support the body from the ground, and are hence used more as pushing organs, though the chameleons have them designed for grasping, the geckos modified into sucking disks, by which they can ascend perpendicular walls, some of the iguanas for swimming, and yet others for digging. It will thus be seen that the animals are designed for different modes of life. While some lizards are terrestrial, and have the limbs poorly developed or even absent, others are arboreal, and, like the arboreal serpents, are specially modified and protectively colored. It is in this order, however, that we first find reptiles designed for an aërial, or partially aërial, life. The shoulder girdle is always present, and the shape of the clavicle is of considerable taxonomic value. The sternum is absent in a single genus, *Amphisbœna.* The ribs are generally present, and extend from the anterior cervical to the lumbar vertebræ. These ribs, in forms like *Draco* and *Liolephis*, are the chief organs of support for the wing-like expansions of the sides of the body.

The structure of the skull is particularly interesting, though complex. On its peculiarities has been based the only natural classification. The cranium proper, that portion of the skull enclosing the brain, is relatively small; it does not extend to the orbital region, and is protected in front by a vertical curtain, the membranous interorbital septum. The bones of the jaw are connected with those of the cranium by the intervention of an arch, the zygomatic, made up of the malar, postorbital, and squamosal bones. The quadrate is large and much more firmly attached than in either of the previous orders. The rigidity with which the bones are united is worthy of notice, and particularly interesting when compared with the loosely articulated facial bones of the serpents. The lower jaw is incapable of lateral expansion, either by means of an elastic symphysis, or by a medial joint.

The dentition is peculiar, and, to a certain extent, characteristic. Much more variety as regards general structure, mode of insertion, and position of teeth, is presented than in the previous orders, though these peculiarities are of only secondary value in classification. In many families there is an interesting distinction between Old and New World forms; the former having the teeth planted along the ridge of the jaw are termed *acrodont*, while the latter have them merely appressed to the inside, and are *plurodont.* A peculiar anomaly is presented by the American genus, *Teius*, the teeth in the young being plurodont, and, as age proceeds, by a growth of the bone of the jaw around their bases gradually becoming acrodont.

Though the shape of the tongue is very variable, and, to a certain extent, characteristic, its covering is of far more importance to the systematic zoologist. Though the lower families and the degraded Amphisbænas have the eyes, like the serpents,

unprotected by lids; the higher forms have well developed lids; some, like the skinks, having the lower so transparent that it performs the office of a nictitating membrane, though closely related forms may have it opaque and scaly. The keen-sighted chameleons have the eye entirely surrounded by the lid, vision being obtained through a central slit.

The integument of lizards, though often provided with scales, is not invariably so protected; the geckos and Amphisbænas offering the most familiar exceptions. The scales, when present, present considerable variety of structure, which is of use in determining the several genera and species. These scales are often of considerable size, especially when connected with the cutaneous expansions of the throat, back, and sides. Along the inside of the thigh and across the abdomen the skin is not infrequently pierced by ducts leading from subcuticular glands. These openings are called pores.

Though the majority of lizards are oviparous, a few, like *Anguis*, *Seps*, and *Phrynosoma*, give birth to their young. With the exception of *Heloderma*, all are perfectly harmless so far as poison is concerned, and are generally of a most timid nature. They are by far the most numerous, and present the greatest variety of coloration in the typical countries.

The classification herein adopted is the most natural, and is based on a thorough study of the anatomical peculiarities of the order, a result of the labors of Professor E. D. Cope and G. A. Boulenger. Twenty-one families are characterized, all of which are treated to a more or less extent.

The first family, Geckonidæ, is easily recognized. It includes a number of the lower developed lizards, which have the centra of the vertebræ concave both anteriorly and posteriorly. They are further characterized by having the tongue short, thick, and fleshy, the eyelids rudimentary, and the pupils of the large eyes generally vertical and elliptical, a peculiarity which points to a nocturnal life. They are all plurodont, and the head is broad and depressed; the body is of moderate breadth, granular above, and covered below with small imbricate scales; the tail is normally thick at the base, and tapering, though it is so often broken off that it is generally somewhat deformed. The limbs are stout, of moderate length, and the well-developed toes are usually provided with an adhesive apparatus, made up of a series of plates or disks, by means of which the animals can run up a perpendicular wall or smooth tree. Though nearly all are provided with claws, the sucking-disks are less perfectly developed in the arboreal forms. The acrid fluid secreted by the disks has given the erroneous idea that the animals are poisonous.

There has been observed in many geckos a peculiar pair of calcareous masses on each side of the neck. These seem to vary in size with different individuals, in some being entirely absent, while in others of the same species they may appear either as a thin layer or as hard rounded masses. No dermal pore has been discovered to connect them with the exterior.

The geckos are small in size, never exceeding fourteen inches in length, and are carnivorous; destroying the larger insects and moths, and are to some extent cannibalistic, eating their own young, and, what seems most surprising, they have been observed to devour their own tail, an organ which they seem to regard as purely ornamental, to be dispensed with whenever the occasion demands. Among themselves they are quarrelsome, and often fight over their prey. They are noisy at night, many being named, as is the gecko, from the peculiarity of their calls.

Platydactylus mauritanicus is found in the countries bordering the Mediterranean and is known in the south of France as the *tarente*. It is never found in damp or shaded localities, but delights in the sunshine, being found about ruins and old walls. The colder portions of the year it spends in an inert condition, hid away in some crevice, or under the tile of an old house, ready to creep out on the first warm days of spring. It is a perfectly harmless animal. Of its cry nothing is known.

FIG. 235. — *Platydactylus mauritanicus*, tarente.

Sphærodactylus notatus, one of the smallest American lizards, measuring about two inches in length, is the only gecko in the United States, though there are three or four in Mexico and Lower California. Each of the toes is terminated by a small rounded disk, by means of which, the animal can wander over the perpendicular faces of rocks. The reptile is very rare in collections, though it has been several times taken in Florida and Cuba. While the scales on the back and sides are large and keeled, those of the belly are smooth, small, and hexagonal.

The genus *Hemidactylus* is very generally distributed through the warmer regions of the globe, and is characterized by having the dilated toes armed beneath by two series of transverse imbricate plates, and the trunk and tail without lateral cutaneous appendages. *H. trihedrus* has the back granulated with numerous trihedral tubercles, some of which equal the opening of the ear in size. The femoral pores do not cross the pre-anal region. This animal, which reaches a length of seven inches, inhabits the coast of Malabar, avoiding the habitations of man, only living in rocks and trees. Of much different habits is the semi-domesticated *H. maculatus*, the most common gecko in India, and extending its geographical range into China, the Philippine Islands, and

FIG. 236. — *Hemidactylus verruculatus*, gecko.

Mauritius. *H. frenatus*, the cheecha of Ceylon, inhabiting also India and possibly south Africa and Polynesia, is a most interesting little animal. But four or five inches in length, it makes its appearance soon after sunset, about the walls of the Indian dwellings, in search of flies or other small insects. If some attention be shown it, however, it will present itself every evening at the accustomed place, where it expects rice or morsels of bread, soon becoming very tame. The female lays three or four eggs in a crevice of some old wall, or possibly in a hollow tree. *H. verruculatus* inhabits the shores of the Mediterranean, where it is often found in cellars. It is of a reddish-gray color, with back and tail covered with conical tubercles.

To the collector in the island of Jamaica, the croaking-lizard, *Thecadactylus*

lævis, is a most abundant, as well as a most interesting, animal, though of repulsive appearance and unfounded bad reputation. It is found everywhere; in the out-buildings, old mills, and cattle-sheds, making its presence known by a singular croaking noise, which it maintains throughout the night, resembling that produced by drawing a stick over the teeth of a comb. The eye is unprotected by lids, and though the pupil is large and circular during the night, in the day time it contracts to a small vertical slit, giving the animal anything but a prepossessing expression, a marked contrast to the meek countenance of the there abundant *Ameivas*. The skin of the croaking gecko is very soft and fragile, tearing, like wet paper, almost on the slightest touch. The conical tubercles of the head and back are more depressed posteriorly, where they are flat and scale-like. The tail is very fragile, though on being lost it is soon and rapidly replaced. One in captivity had a new appendage grow to the length of an inch and a half in less than three months. The female has a special place, some crevice in a tree, to which she repairs every little while and deposits an egg, sometimes these are found to the number of eight or nine, firmly glued together, and containing embryos in different stages of development.

The flying-gecko, *Ptychozoon homalocephalum*, is well worthy of notice, being among the lizards what the flying-squirrel is among the rodents. The toes are well spread apart, armed below with a single series of undivided transverse plates, and all but the thumbs are terminated by claws. The most wonderful developments, however, are the wing-like expansions of the skin, which appear as horizontal plates, extending from the sides of the head, body, and tail, and continued as flaps on each side of the limbs, and as webs between the toes. These dermal expansions are only used when the animal is leaping; they then act as a parachute, in the same way as the so-called wings of the flying-dragon. When at rest, a series of muscles draw them close to the body, so that they offer no hindrance to the animal's movements.

The flying-geckos are very beautiful and interesting. Cantor observed a pair which he kept for some time in confinement. The power of changing the shade of the body was possessed only to a limited degree. The female, after neglecting for some time an egg which she had laid, finally disposed of it by using it as food. The male was also equally economical, always devouring his exuviated skin.

The Xantus gecko, *Phyllodactylus xanti*, was described in 1863 by Professor Cope from a specimen obtained at Cape St. Lucas by the person to whom it was dedicated. Since that time several more have been captured in the same locality. They are about nine inches in length, and ornamented with fine blackish cross-bars, which continue on the tail as rings. *Diplodactylus unctus* is also a native of Lower California, where it is called the St. Lucas gecko. It differs from *P. xanti*, which it about equals in size, in several structural peculiarities, though both genera are alike in having the toes provided along the under side with two rows of membranous plates.

The family Eublepharidæ includes a small number of gecko-like lizards, which differ from the members of the previous family, however, in having the vertebræ procœlian, *i. e.*, with the centra concave anteriorly, and in a few other skeletal peculiarities. Three genera are included, one from each of the three continents, Asia, Africa, and America.

Eublepharis hardwickii is a rare form inhabiting India, where it ordinarily passes for a gecko, though on examination it is evidently of entirely different habits. Its toes, not being compressed or dilated, prevent it from climbing any plane of more than ordinary inclination, while the short, stout claws, show it to be a terrestrial

animal, which habit is also indicated by its ordinary scaly toes. The body, as well as the head and limbs, are covered with tubercles of varying size, while the lower parts are protected by small imbricate scales. The tail is thick and cylindrical, and covered with rings of small sub-quadrangular scales, which on its dorsum appear as flat tubercles.

The American genus *Coleonyx* is represented in Texas, California, and the Colorado desert by a rare animal, *C. variegatus*, or the variegated gecko. In coloring, it is, above, of a brownish yellow, ornamented with irregular blotches of reddish brown, which sometimes are arranged as transverse bands. Along the edges of the eye-lid, as well as the entire under surface, a pure white color obtains. The toes bear claws. *Psilodactylus* is an allied form inhabiting West Africa.

The family Uroplatidæ is the first of a large number of families which resemble each other in having the tongue either smooth or covered with villose papillæ, never

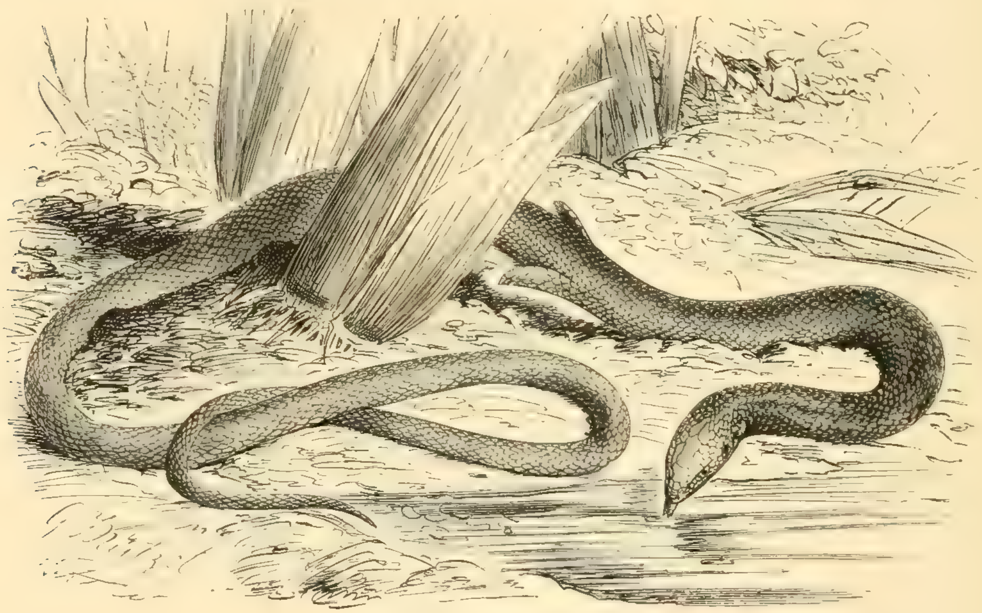


Fig. 237. — *Pygopus lepidopus.*

with scale-like papillæ, and in having the proximal portion of the clavicle dilated. It has the vertebræ concave on both faces, and several peculiarities in the arrangement of the bones of the head. But a single genus, *Uroplates*, is known, of which *U. fimbriatus*, the famocantrata, inhabits Madagascar, and was first mentioned in an early history of that island in 1658. It is a peculiar animal with webbed toes, and with a series of fringes passing down the sides of the head, body, and tail, which latter is described as being much shorter than the body, and oar shaped. The natives, from the animal's habit of running at them with open mouth, particularly dislike this harmless form, even considering it to be of a poisonous nature, and pretending that, by its membranes, it so adheres to the breast, the portion of the body which they claim it always attacks, that a razor is necessary to free it from the skin.

The family Pygopodidæ is represented by the genus *Pygopus*, which is found in Australia, and has the body cylindrical and elongate, the eyelid rudimentary, im-

movable and scaly, and only a single pair of limbs, the posterior, which are scaly and undivided. *P. lepidopus* has the scales of the back keeled, and the pre-anal pores numerous. In its general structure and habits it resembles *Pseudopus*. *Delma* is an allied genus, having smooth scales, no pre-anal pores, and shorter rudiments of hind limbs, while *Aprasia*, of the same habitat, western Australia, has no indication of limbs whatever.

We now come to one of the more interesting families, the AGAMIDÆ, which is represented in the eastern hemisphere by several acrodont genera.

Agama proper has the body covered with keeled scales, the head triangular, the tail round and covered with imbricate scales, the femoral pores absent, and the pre-anals in a row across the abdomen. *A. cœlaticeps* inhabits the warmer portions of Africa, being particularly partial to dry and arid localities, where it is very watchful and suspicious. If it cannot intimidate the object of its disturbance by its gesticulations, it quickly retreats and conceals itself.

The genus *Calotes* inhabits India and Ceylon, and includes several species which resemble each other in having the tympanum naked; the scales of the back and sides equal, regularly arranged, and their tips directed slightly upward; the dorsal crest formed of non-united spines; the gular sac but slightly developed; the sub-caudal scales as broad as long, and the femoral pores absent. The representatives are all arboreal, feeding on insects, tender leaves, and berries. *C. versicolor*, the so-called 'blood-sucker,' is one of the most common animals of the whole continent, extending north into the cooler zones of the Himmalehs. The vernacular name was perhaps given because of the occasional reddish hue of its throat. The female deposits her eggs, sometimes to the number of sixteen, in the hollows of trees, or in holes which she digs in the earth; the young appearing after a lapse of eight or nine weeks. During and after showers these animals often descend to the ground, to search for the numerous larvæ and small insects which are washed from the trees.

The genus *Draco* is characterized by a most remarkable growth along the sides of the body, the skin being horizontally spread out as a parachute and supported by five or six false posterior ribs. A pendant appendage like that of the iguana is also present.

The members of this genus, the flying-dragons, are confined to the East Indies, where they lead an arboreal life, lightly shooting from tree to tree by means of their expanded parachutes, or, with these folded to the side of the body, running along like ordinary members of the order, and resembling in their general habits the *Anoles* of the New World. The several species are extremely similar, the distinctions being chiefly based on the relative length of limbs, the position of the nostrils, and the general scutellation. The tail is undoubtedly of considerable assistance in directing their course through the air; to this end it is long and slender, and more firmly articulated than that of less aërial relatives. Cantor, in speaking of the flying-dragons, says: "The transcendent beauty of their colors baffles description. As the lizard lies in the shade, along the trunk of a tree, the colors at a distance appear like a mixture of brown and gray, and renders it scarcely distinguishable from the bark. Thus it remains with no signs of life except the restless eyes, watching passing insects, which, suddenly expanding its wings, it seizes with a sometimes considerable, unerring leap. The lizard itself appears to possess no power of changing its colors."

The several species, of which there are fourteen, are between seven and eight inches in length. Three or four whitish eggs are occasionally found in the females.

D. volans inhabits Java, Sumatra, Borneo, and has been taken at Singapore and Penang.

The frilled-lizard, *Chlamydosaurus kingii*, is an animal of considerable size, nearly reaching the length of three feet, and inhabiting Australia. It is provided, when adult, with an enormous frill or collar attached on each side of the neck behind the ears, which ordinarly lies upon the sides of the body, though, when the animal is excited, the structure is quickly elevated and brought forward, like an inverted umbrella, and being beset on both sides with large keeled scales, is of considerable value as a shield of defence.

FIG. 238. — *Chlamydosaurus kingii*, frilled lizard.

Captain Grey, in writing of this animal, says: "As we were pursuing our walk in the afternoon, we fell in with a specimen of the remarkable frilled-lizard. It lives principally in trees, though it can run very swiftly along the ground. When not provoked or disturbed it moves quietly about, with its frill lying back in plaits upon the body; but it is very irascible, and, directly it is frightened, it elevates the frill or ruff, and makes for a tree, where, if overtaken, it throws itself on its stern, raising its head and chest as high as it can upon the fore legs, then, doubling its head underneath the body, and displaying a very formidable set of teeth from the cavity of its large frill, it boldly faces an opponent, biting furiously at whatever is presented to it, and even venturing so far in its rage as to fairly make a charge at its enemy."

The genus *Histiurus* has the compressed back and tail armed with a crest; that of the tail being much the larger. A representative is the sail-lizard, *H. amboinensis*, so called from the enormous perpendicular development surmounting its tail. It is one of the largest tree-lizards, being nearly four feet in length, and is of a general brown color, shading into green on the neck and head. The animal is chiefly known through the writings of Valentyn, the early Dutch traveler and divine, who found it in the island of Amboyna, where it lived in the woods and thickets bordering streams. The diet, besides seeds and berries, is made up of water-plants, worms, millepedes, and such like. When it is frightened it seeks safety by diving and hiding under some submerged rock, from which retreat, being exceedingly stupid, it will allow itself to be taken in

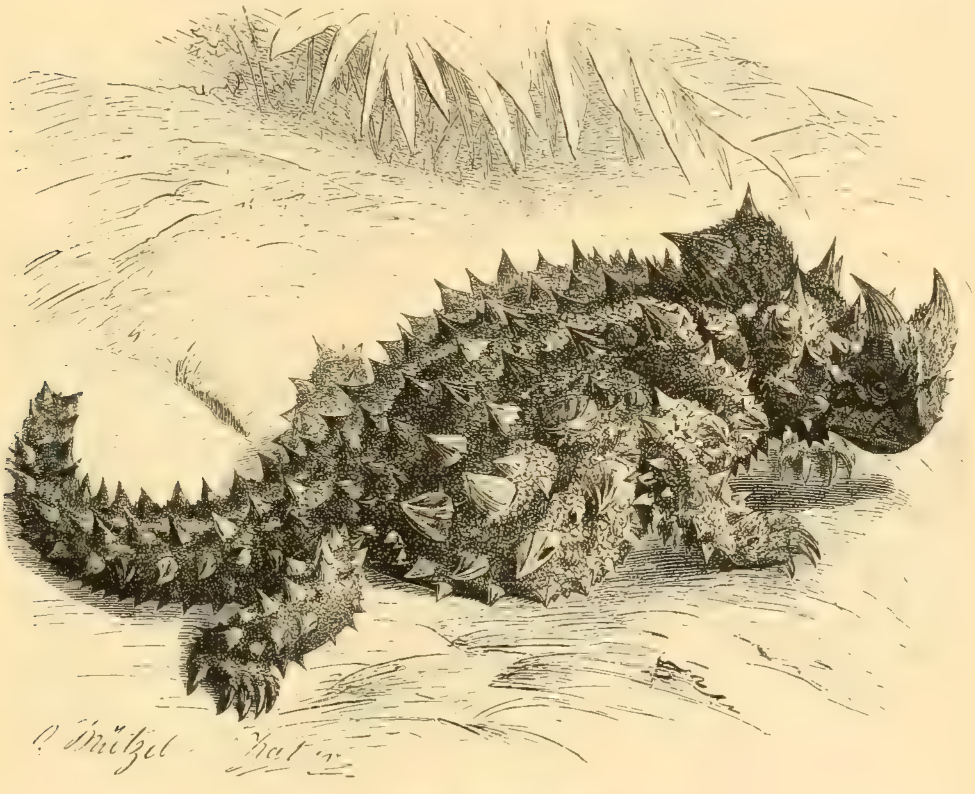


FIG. 239. — *Moloch horridus.*

a net, or may even be grasped by the hand, not offering the slightest opposition to its capture. The natives destroy large numbers of them for food, the flesh being white, tender, and very palatable.

The genus *Phrynocephalus* is restricted to central Asia, and may be recognized by the stout head and anteriorly directed nostrils. The tongue is not notched, but slightly pointed; the eyes small, with well-developed lids, of which the upper is rudimentary and hidden below the projecting superciliary ridge. The body is much depressed and covered above with minute scales, which along the sides become granular; the legs are well developed and are without pores. The tail is said to be prehensile, though this is doubtful.

The Australian moloch, *Moloch horridus*, is one of the most repulsive creatures of nature. While many of our lizards are protected by thorny scales, and some of the *Phrynosomas* have the head armed with horns, the moloch actually bristles with strong, conical spikes, those surmounting the crown and those over the eyes being particularly long and stout. On the back of the neck is a large rounded protuberance covered with spines and having the appearance of a second head. The larger spines of the back and sides are simply conical growths of skin capped by a thin horny covering, and supported by surrounding dermal outgrowths of a similar nature, though of smaller size.

Liolephis, a native of the Malay Peninsula and China, is represented by but a single species, *L. sulcatus*, which reaches a length of about twenty inches. The genus is characterized by having the tympanum naked; the scales small and without keels, the femoral pores present, and by having, and chiefly, the skin of the sides of the body capable of expansion into wing-like organs, which are supported by very long anterior spurious ribs. When the animal is in a state of repose, or is simply wandering among the branches, these organs are appressed to the sides of the body and appear as mere longitudinal dermal folds. But when wishing to pass to some remote position, or if merely agitated by sudden fear or anger, the six anterior ribs, which are greatly elongated, are brought forward, expanding the membranous skin, to which the fore and hind limbs are juxtaposed, and the thus greatly expanded reptile sails off to a neighboring tree, as gracefully as the flying-squirrel. These lizards are naturally very active, and will defend themselves with tooth and nail on being captured. In confinement, however, they soon become tame, and feed on rice and soft fruits.

The genus *Stellio* has the tympanum naked and the body depressed; the scales are spiny on the tail and unequal in size. No pores are present. *S. tuberculatus* inhabits India, and is dusky brown above, speckled with black, and below whitish passing into green on the throat. They have been found on the mountains of Thibet as high as 15,000 feet. Specimens over a foot in length are rare. *S. vulgaris*, called 'hardim' by the Arabs, is found in those countries bordering on the eastern Mediterranean, and is particularly abundant about the ruins of ancient buildings, where, during the warmer portions of the day, they may be counted by the hundreds. They are always busy, scrambling over the hot surfaces of the stones after flies and ants, only stopping to nod their heads, — a habit, by the way, which has resulted in the death of many an innocent, the Mohammedans supposing that the reptiles are mocking in derision their form of worship. The hardims are of an olive-green color shaded with black, and below a pale yellow.

The members of the family Iguanidæ are plurodont lizards confined to the warmer portions of the New World. The body, in the more typical forms, is laterally compressed and supported by limbs which are designed for an arboreal life, though forms like *Phrynosoma* may be depressed and terrestrial, while others of different habits may have the body adapted to an aquatic life.

The genus *Polychrus* has the quadrangular head covered with numerous appressed shields; the back without a crest; the skin of the gullet compressed into a small dewlap, and the body covered with smooth scales, which allow the changes in coloration below to be easily studied. *P. marmoratus*, the marbled Polychrus, inhabits Brazil and Central America.

The genus *Iguana*, the one most typical of the family, has the head pyramidal,

Iguana tuberculata, iguana.

and often raised along the crown like a helmet; the tongue thick, and but slightly notched, and the dorsal crest well developed. The tuberculated lizard, *I. tuberculata* of the West Indies and South America, is the most familiar type both in illustrations and as museum and menagerie specimens. To those unfamiliar with the animal, it presents an uncouth and most repulsive appearance. Its compressed body, high dorsal ridge, and enormous dewlap give to it more the appearance of some taxidermist's fancy than an animal naturally designed and modified. Though in confinement slow and inactive, it soon learns to know its keeper, to whom it shows a decided preference. In their native haunts, during the warmer portions of the day, they climb some low tree and stretch themselves in the sun, their tail hanging down like that of a snake. When thus basking they are not easily aroused, and, perhaps trusting too much to their protective color, can be closely approached without evincing any alarm. The natives take advantage of this indifference, and while the animal thus lies gently eyeing the intruder, a noose attached to a long stick is slipped over its head, and the unsuspecting animal immediately finds itself jerked from its elevated position to fall a victim to the omnivorous appetite of man. Being an exclusive vegetarian, feeding on flowers, fruits, and fungi, and especially on the leaves of the mangrove, its flesh is palatable, and is white, tender, and nutritious. The pious Père Labat gave, two centuries ago, a very interesting account of the manner in which he saw them captured. " We were attended by a negro who carried a long rod, at one end of which was a piece of whip-cord with a running knot. After beating about the bushes for some time the negro discovered our game basking in the sun on the dry limb of a tree. Hereupon he began whistling with all his might, to which the guana was wonderfully attentive, stretching out his neck and turning his head as if to enjoy it more fully. The negro now approached, still whistling, and advanced this rod gently, began tickling with the end of it the sides and throat of the guana, who seemed mightily pleased with the operation, for he turned on his back and stretched himself out like a cat before the fire and at length fell asleep, which the negro perceiving, dexterously slipped a noose over his head, and with a jerk brought him to the ground. And good sport it afforded, to see the creature swell like a turkey-cock to find himself entrapped. We caught more in the same way, and kept one alive seven or eight days; but it greaved me to the heart to find that he thereby lost much delicious fat." Not only are the iguanas captured in this way, but they are often chased to their burrows or treed by dogs trained for the purpose. They are ordinarily captured alive, and carried to market by people who thus earn a living at certain seasons of the year. The tuberculated lizard does not often exceed the length of five feet.

The naked-necked iguana, *I. delicatissima*, also inhabits the more tropical portions of America, and is, too, an important animal for food. In general form and habits it resembles its more abundant relative, though the neck has no large tubercles, and the cuticular appendage of the chin is small and with only few denticulations. The horned-iguana of San Domingo, *I. cornuta*, is characterized by having a conical osseous point between the eyes, and two raised scales on the nostrils. Though, like the previous species, the scales along the jaws are well developed, there are no tubercles on the neck nor broad plate below the ears. The teeth of this and other related iguanas are very peculiar and characteristic. Not only are they placed along the inside of each jaw, merely attached instead of inserted into alveoli, so that the reserve of incipient teeth have little difficulty in supplying the place of those broken off, but the crowns of the teeth are laterally compressed, and the edges denticulate, bearing

in outline a shape not unlike that of a rounded elm leaf. This structure is very characteristic and has been of considerable value to geologists, as, on finding teeth of a similar nature in several of the Dinosaurs, they are upheld in inferring that these extinct forms had many points in common with the more recent.

Mr. Darwin gives a most interesting account of the lizards of the genus *Amblyrhynchus.* These animals are restricted to, and characteristic of, the Galapagos Islands, a small archipelago lying on the equator, five or six hundred miles west from the Pacific coast of South America. The generic name has been given to these peculiar reptiles because of their abbreviated snout, the head being formed like that of some of the sea-turtles, and though the two species are both vegetable feeders, and

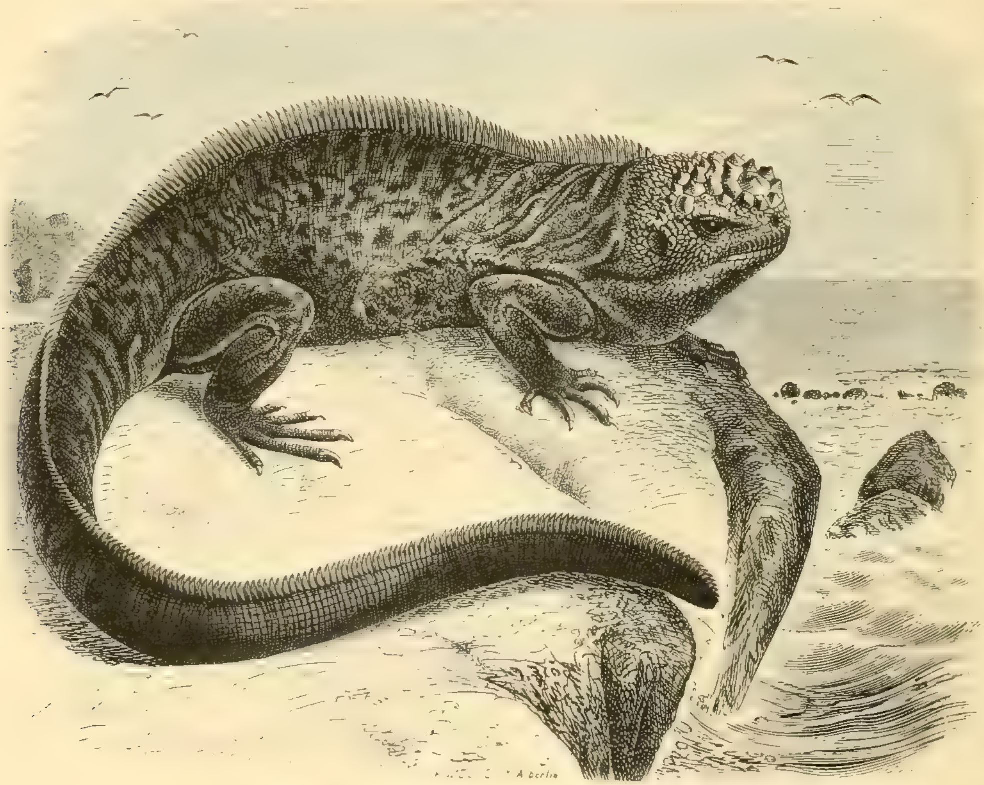


FIG. 240. *Amblyrhynchus cristatus*, Galapagos lizard.

are acknowledged to be of the same genus, they are of the most opposite habits, one being purely marine, never retreating but a few feet from the shore, and feeding exclusively on seaweeds, while the other is terrestrial, feeding on cacti and acacia leaves.

A. cristatus, the marine representative, is very abundant on all the islands of the group, in some situations so congregating as they lie basking in the sun as to almost line the rocks along the shore. Though allied to the iguana, the tail is laterally compressed and serves as the chief organ of locomotion, as the animal by horizontal flexions of its body, propels itself through the water; the limbs, with the partially webbed toes, being appressed to the sides and only used to give an occasional push as the animal glides along near the rocky bottom in search of the soft green

foliaceous seaweeds (Ulvæ), plants which are also abundantly found on our shores. Though so pre-eminently an aquatic animal, having been known to live for an hour below the surface, it is a strange fact that on the apprehension of danger, whether from land or sea, it invariably takes to the shore. This anomalous habit may be explained by the fact that its original and only enemy may have been some predaceous shark, to escape which its only safety was in flying to the shore, which by an hereditary instinct became to it the only place of refuge. Mr. Darwin says: "It is easy to drive these lizards down to any little point overhanging the sea, where they will sooner allow a person to catch hold of their tails than jump into the water. They do not seem to have any notion of biting, but when much frightened they squirt a drop of fluid from each nostril. I threw one several times as far as I could into a deep pool left by the retiring tide, but it invariably returned in a direct line to the spot where I stood. It swam near the bottom with a very graceful and rapid movement, and occasionally aided itself over the uneven ground by its feet. As soon as it arrived near the edge, but still being under water, it tried to conceal itself in the tufts of seaweed, or it entered some crevice. As soon as it thought the danger past, it crawled out on the dry rocks and shuffled away as quickly as it could. I several times caught this same lizard by driving it down to a point; and though possessed of such perfect powers of diving and swimming, nothing could induce it to enter the water, and, as often as I threw it in, it returned in the manner above described." The animal is of a dirty black color and of about a yard in length. Of its breeding habits nothing is known.

A. demarlii, the terrestrial species, differs from the previous in having the tail cylindrical, and the toes without webs. The individuals of this species, though not found in all the islands of the archipelago, are on some so abundant that it is with considerable difficulty that a plat of ground, free from their burrows, large enough to pitch a tent on, can be found. These burrows being dug at but a small angle with the surface of the ground, are so poorly roofed over as to make traveling very difficult and tiresome, the soil constantly giving way. The animals, which are somewhat smaller than those of the previous species, are lazy, half torpid, and in their motions semi-mechanical. When running along the surface of the parched soil they often stop and doze, their eyes closed, and their hind legs awkwardly spread out. They are diurnal, and seldom wander from their burrows, to which they immediately retreat on being disturbed, and with a most awkward gait. They are not timorous, however, often elevating themselves and watching one with the drollest expression. After considerable irritation they can be made to bite, though they are otherwise perfectly harmless. Those that inhabit the more arid portions of the islands, are compelled to go for long periods without tasting water, though they consume great quantities of the succulent cactus, to which plant they are very partial, as are most of the animals of the locality. The birds seem to be well aware of the mild disposition of these animals, as they not infrequently eat of the same fragment, and have been even known to perch upon the reptile's back. These lizards, as well as their eggs, which are laid in their burrows, are used as food by those — as Darwin characterizes them — "whose stomachs soar above all prejudices."

Members of the genus *Metapoceros* are found on the islands of Navaza and Haiti, where they are large and strong. The older specimens are peculiar in having, under the basal joints of the third and fourth toes and the second joint of the third toe, a number of scale-like scrapers.

The genus *Cyclura* was distinguished as early as 1825, when it was applied to those lizards which have a general resemblance to the iguanas ; three species are now known to inhabit the peninsula of Lower California. *C. teres*, the smooth-backed Cyclura, has a length of about twenty inches, and is of a general dark-green color Like others of the genus it has a loose fold of skin below its throat, a structure that is maintained by some to be indicative of an irritable disposition. The comb-like spines appear as a low ridge running from the occiput to the sacral region, where after a short interspace, the more prickly caudal crest begins, sending out laterally about two dozen spiniferous branches, which extend as rings completely around the tail, though the spines decrease in size as they leave the dorsal line. On the inside of

FIG. 241. — *Cyclura lophoma*, great iguana.

each thigh is a row of seven glandular orifices. *C. hemilopha* has the scales of the dorsal crest along the nape considerably elongated, though they soon diminish in size, entirely disappearing at about the middle of the back. *C. acanthura* is the spine-tailed lizard described by Shaw in 1802. It is a rare animal, inhabiting Lower California. *C. lophoma* is the great 'iguana' of eastern Jamaica, and is provided with an elongated dorsal crest like the teeth of a saw. Like the lizards of the related genus *Iguana*, this animal spends most of its time, during the warmer portions of the day, lying out on the sunny branches of some tree.

The range of *Basiliscus* extends northward into southern Mexico. In novelty of appearance this animal rivals the Australian *Chlamydosaurus*. The basilisk proper

is one of those animals mixed up in the superstitious traditions of the ancients, and still regarded by some with the greatest awe, being to them the king of the reptile race, bearing a crown as a symbol of his sovereign rule. It was thought that he had no regular occupation, and that he feasted on an egg laid by a cock and incubated by a snake, though that the egg was thus incubated was denied by some 'naturalists,' who maintained that a toad performed that arduous task. From the glance of this

FIG. 242. — *Basiliscus mitratus*, basilisk.

mighty reptile's eye, death and destruction spread. "This poison," writes an author, "infecteth the air, and the air so infected killeth all living things, and likewise all green things, fruits and plants of the earth; it burneth up the grass whereupon it goeth or creepeth, and the fouls of the air fall down dead when they come near his den or lodging. Sometimes he biteth a man or beast, and by that wound the blood turneth into choler, and so the whole body becometh yellow or gold, presently killing all that touch it or come near it." The cock was the only animal before whom this

terrible reptile would cower, and that the travelers of the deserts might be protected, they often carried with them a supply of these loud-voiced chanticleers.

Such are the traditions connected with the name of a harmless, inoffensive animal, seldom exceeding the length of three feet, and inhabiting the forests of Guiana and Martinique. It differs from the other members of the family in not possessing the long extensible skin of the throat, and in being provided with an elevated unsegmented crest along its back, and a second along the dorsal side of the tail, which is strengthened by the elongated spinous processes of the vertebral column. Though it might be inferred from the compressed tail that the animal is aquatic, such is not the case, as it lives an arboreal life, preferring the low branches of trees in the neighborhood of some quiet brook. Upon the occiput is a most singular hood-shaped crown, which is said to be capable of considerable distention.

FIG. 243. — *Anolis principalis*, American chameleon.

The widely distributed genus *Anolis* is represented in the United States by two species, of which *A. principalis*, inhabiting the southern states, is by far the most abundant, and is known as the American chameleon, or scorpion. The figure of this animal is considerably enlarged, as its body seldom exceeds the length of three inches and a half, though the elongated tail may be half a foot in length. The entire animal is covered by minute scales, those of the jaws and head being somewhat larger, and regularly arranged. The gape of the mouth is capacious, and the ear opens just back of its commissure. The dewlap extends from the chin to the sternum, and by a special arrangement can be vertically expanded like a fan, when it is of a deep red shade, or may be retracted so as to be scarcely visible. Though the general color of the animal below is white, above it may assume almost instantly shades varying from a beautiful emerald to a dark and iridescent bronze color.

The chameleons are particularly abundant about cemeteries, finding a ready means of retreat in the chinks of the old oven-like tombs of the south. They are not confined to these situations, however, but abound everywhere; on fences, plank-walks, wharves, dry weeds, and brushwood. When on the broad green leaves of the palmetto, when searched for from above, they are with considerable difficulty perceived, so exactly is the color of the leaf counterfeited; though, on looking on the lower side of the leaf, their dark shadow is very distinct. Few animals exhibit mimicry of color to a greater extent than does this. Not only is the color constantly changing and passing from light to shade, but a passing cloud may cause the customary bright emerald to fade. When surprised, the 'chameleon' eyes the intruder, remaining perfectly motionless until some action frightens him, when, with a dart, he is out of sight, all but his caudal appendage, a bit of vanity which is seized upon by the collector, and as it is better articulated than that of lizards' tails generally, its owner, though involuntarily, falls a victim to "the bottle." But not always does he value his tail more than life; after a short struggle he often frees himself, leaving a bit of it behind, and scampering around bob-tailed until the lost part is renewed. The *Anolis* has many enemies to contend with, of which the most common and most uncompromising is the cat. It is said that this animal will leave anything — meat, birds, and even fish — at the slightest chance of securing one of these lizards.

From an economic standpoint the *Anolis* is a most important agent in restricting the inordinate multiplication of insects, of which it devours great numbers. Though retiring early and sleeping late, they are abroad and at work during the warmer portions of the day, when their prey is most abundant, and when other insectivorous animals seek the quiet of retirement.

Two species of *Anolis*, *iodiurus*, and *opalinus*, are very abundant in Jamaica, where they entertain the visitor by their gambols and scrimmages. Indoors they are very abundant, scrambling over the furniture and walls in search of insects, being particularly destructive to the ants, and not infrequently do they jump on one's clothing without evincing the slightest fear, all the time changing their hue from shades of golden green to dark bronze brown.

The genus *Sceloporus* includes a large number of American lizards which have the head covered with small shields; the back and tail with large keeled scales; the belly with smooth scales, and the femoral pores large. The members have until lately been included under the name *Tropidolepis*.

Sceloporus consubrinus is very generally distributed over the west, and extends north to the Yellowstone. In Arizona it is not only abundant with other lizards in the desert portions of the south, but is also a common inhabitant of the high, dry plains of the mountains. *S. gratiosus* is a second widely distributed species. It has the scales of the back larger than those of other portions of the body. It inhabits the sandy situations along the Colorado River, and other similar localities in the west. The different individuals present considerable variation in color, due to the surroundings of the frequented situations. *S. spinosus*, an inhabitant of Texas and Mexico, reaches nearly a foot in length. Its rough carinate scales would give it a most repulsive appearance were it not that the reptile is beautifully maculated with purplish black blotches. The ear opening is armed by three projecting spines, and the body has about a dozen dark spots each side of the dorsal line.

Of about a score of species of the genus found north of Central America, but a single representative, *S. undulatus*, crosses the Mississippi. This species extends

northward to the Ohio River, and even into New York. It prefers the more sandy localities covered with pine, and is often called the 'pine-lizard.' It is a most active animal, quickly scurrying away on being disturbed, and with such celerity that the little reptile is in some localities called the 'swift.' Though elsewhere known as the 'alligator,' and 'brown-scorpion,' it is a most gentle and harmless animal, in confinement having many odd traits. When irritated it elevates its spinous scales, rapidly changes its color, and looks withal a most formidable antagonist. In its free state it may be often seen basking in the sun, on some old fence, or perhaps among the lofty branches of some tall pine, being so rapid in its movements that it can be captured only under the most — to the collector — favorable circumstances. In its coloring it is a beautiful animal. The dark chestnut back is banded with half a dozen undulating black stripes, having along their posterior borders a pair of light-gray blotches, those of a side often becoming contiguous. The silvery abdomen is ornamented on each side by a broad and elongated patch of a blue or green color, bordered with black. The tail, which considerably exceeds the body in length, is slender, and of a dusky color, banded transversely with black.

The genus *Uta* is of particular interest to American herpetologists, from the fact that it combines some of the characters of *Sceloporus*, as the similar shielding of the head, and in being provided with auditory apertures, with the general body scutellation, neck-ring, and disposition of pores of *Holbrookia*. *Uta* differs from both genera, however, in having the scales of the tail much enlarged, calling to mind the same appendage of *Crotaphytus*.

Uta stansburiana, one of the most beautiful and graceful lacertilians peculiar to North America, has the slender and elongated tail provided with large, vertically arranged scales, and the lower surface of the neck with a transverse sub-lingular fold in addition to the pectoral. The color above is blackish-brown, marbled with lighter dots. Below it is of a uniform greenish-yellow, variegated with brownish-yellow bands. Stansbury's uta has a wide distribution along the Pacific coast, Lower California, the Sonoran region, Nevada, and the valley of the Great Salt Lake. Within this territory are also found about half a dozen other members of the genus.

Dipsosaurus is another western genus, and has but a single species, *D. dorsalis*, specimens of which have been captured along the Colorado and in Lower California. On being surprised, this animal carries its body high above the ground, and, elevating its tail like a squirrel, scampers over the sand to its burrow with great celerity.

The genus *Crotaphytus*, which has the head covered with small polygonal plates, the jaws, pterygoid, and palatine bones armed with teeth; the auditory aperture broad; the femurs provided with pores, and the tail extremely elongated, is peculiar to North America, and resembles *Holbrookia* in the general arrangement of the teeth, and in having but a single occipital plate, though it differs in having the external auditory apertures open. *C. collaris* was the first published species, and was described from specimens collected by members of Long's expedition. It is now known to inhabit the central region of the West, as far north as 40°. It is one of the most active species of the group, and is quite difficult to capture alive. Dr. Coues endeavored to keep several in confinement, but they proved untamable, and "not only defended themselves with spirit and vigor, by biting when handled or irritated, but sometimes assumed the offensive, leaping to attack to the full length of the cord which confined them. Their behavior was in striking contrast to that of the horned frogs picketed with them. The lizards lay sullen, but not cowed, watching every

movement of the persons around them with glittering eyes, ready to spring upon an intruder without warning. They clung tenaciously to a stick or the finger, in which they might fix their teeth, and suffered themselves to be suspended in this manner for some time before relinquishing hold. Now and then they seemed to have a fit of ungovernable rage, during which they leaped aimlessly about, and tugged persistently at the cord. They refused to eat, apparently from pure chagrin, and all died within a few days." *C. wislizenii*, inhabiting the country further west to the Pacific, and south into Mexico, is closely allied. It probably lives on smaller lizards, as a species of *Cnemidophorus* has been dissected from the stomach of one. *C. reticulatus* inhabits western Texas. I learn through Dr. Yarrow that both species of *Crotaphytus* are eagerly sought after by the lower classes of Indians of western Utah and eastern Nevada. To capture them the Indians employ a long switch armed at one end with a hook, which is generally made from a bent nail or piece of wire. With this instrument the lizards are drawn from their burrows and then tied up with other unfortunates. In the National Museum are several of these hooked sticks, some of which are from the Apaches of New Mexico.

Uma has the ears distinct; the palate without teeth; the infraorbital plate very

FIG. 244. — *Crotaphytus wislizenii.*

long; the imbricate labials oblique, and the claws long, slender, and straight. *U. notata* is of a light pea-green color above, spotted with darker green, and beneath white. It is a small form, the body being about two inches in length, in rare cases found in the Mohave desert. *Sauromalus ater*, the alderman-lizard, though rare in collections, abounds on Angel Island, in the Gulf of California. It is a large and stout animal, sometimes exceeding a foot in length. The head is nearly as broad as it is long, and the tail does not equal the body in length. Though the young are quite gayly ornamented, the adults are of a reddish dirt-color. *Callisaurus dracontoides* is represented by three varieties, which are known respectively as the Californian dragon, inhabiting southern Lower California; the spotted-tailed dragon, found around Sonora; and Gabb's dragon, which inhabits the northern portions of Lower California. The ear openings prevent the members of this genus from being confounded with those of the next.

The genus *Holbrookia* was dedicated to the American herpetologist, Dr. J. E. Holbrook, in 1850, by Girard, and includes a small lizard of most interesting structure, though of only ordinary aspect. Its resemblance to *Crotaphytus* is destroyed

by its having no auditory aperture, and it is a much more stumpy as well as a smaller animal. There are no teeth on the palatine bones; a fold of skin crosses the pectoral region, and only femoral pores are present. *H. maculata* is rather short and thick; more so in the female than male, the entire length being between three and four inches. The tympanum is covered by scales similar to those of the neck. Running across the lower jaw from the angles is a fold of skin, smaller though parallel to the second or pectoral. The general color is olivaceous brown, passing into dim violet on the sides of the head, and ornamented on the back and sides by dark-brown blotches.

Holbrook's lizard is found in the central and southern portions of the west, where it inhabits the burrows of the prairie dog, *Arctomys ludoviciana*. *H. propinqua* and *texana* are more limited in their distribution, being only found in Texas and the neighboring portions of Mexico.

We now come to the more depressed members of the family, which, having the legs short and appended more to the sides, give the animals a toad-like appearance. They are mostly terrestrial, hiding in pits and holes of the ground, usually selecting stony and sandy localities.

Few lizards are better known as objects of curiosity than those popularly called, at home and abroad, 'horned or California toads.' From their odd appearance they at once attract attention; and having a most quiet disposition, seldom offering to bite, and soon becoming accustomed to domestic life, they are seized upon as pets by travelers, and have even been used as jewelry, being tethered by a slender chain to a breast-pin. Not only are they interesting from their habits while domesticated, but many of their ways in nature are strange and unusual. There are no less than nine different species of these animals inhabiting the country west of the Mississippi, from Mexico to Dakota, all being included under the single generic title *Phrynosoma*, indicative of their toad-like appearance. No genus of the order is more easily recognized than this. The body is more or less circular in outline, extremely depressed, and covered above with spine-like scales, which extend on to and cover the short conical tail. The solid sub-triangular head is provided with carina over the eyes, which are thus placed in a groove and are minute. Strong horny spines are often developed from the superciliary and temporal regions, as well as across the occiput. The pyramidal scales of the back are greatly developed in *P. cornuta*, an animal which presents a most roughened and spiny appearance. In *P. platyrhinos* and *modestum* the body is quite smooth, and destitute of the roughness generally characteristic of the group. The scales of the lower side of the neck and body are important in characterizing the several species. On the breast and anterior portion of the shoulders the largest scales appear, being here very prominent, acute posteriorly, and provided with strong ridges or keels. The relative portions of the thighs are similarly protected, though with much weaker scales. The legs are of about equal size, and used not for jumping, but for running; the popular name "toad" being given more because of the animal's general appearance than from any relation to the Batrachians. Though the anal pores are absent, those of the thighs are present, and of different numbers in the several species.

Phrynosoma douglassi is wide-spread over the entire western plains, extending its habitat from British America into Mexico, and presenting two accepted varieties; the coloring of different individuals from different localities shows considerable variation, ranging from a uniform brown shade above, to a spotted or barred ornamentation; infrequently the sides of the head are red. Below, the color may be of a

uniform pale gray, or blotched with brown. The young individuals are also different from the adults, being of a more uniform and lighter color. The color of all *Phrynosomas*, however, is due to a greater or less extent to the color of the soil on which they live. Probably no reptile presents this peculiar adaptation more than do the representatives of this genus; often so accurately are the surrounding shades of color counterfeited that it is impossible to distinguish the reptile. This coloration, moreover, is not simply transitory, as in the chameleons and other lizards, but is more permanent, and only changes after the animal has been placed on a new soil for a considerable length of time. In confinement, which may be easily effected by tying a small string to the animal's horns, it is a most inoffensive creature, and though the larger ones may at first offer a little resistance on being captured, they soon, with care and kindly handling, become accustomed to a domestic life, and may become quite tame

FIG. 245. — *Phrynosoma orbiculare*, horned-toad.

and live for months. They have been known to take milk and flies from the fingers of their keepers. They are most bashful animals, when they think they are being observed, as well as when roughly treated, depressing their bodies, and with closed eyes feigning death to perfection. A little tickling along the side will bring them to life, however, and please them hugely, they expressing their fondness for the operation by inflating themselves until they are nearly spherical. They also seem particularly pleased if the rain is allowed to fall upon them. This contentment is only transitory, however, for no sooner is their keeper lost to sight than they try some plan of escape; shuffling away with a rapid gait, or seeking concealment by drawing the limbs to the body, depressing the head, and with a few wrigglings, disappearing into the earth. *Phrynosoma orbiculare* is a Mexican form.

It is said that the horned toads have special aversion for dogs, on the sight of one, puffing up their body, lowering their horns in a most ludicrous manner, and hissing like a turtle. Their food consists of flies and other small insects, ants being particular

favorites. All *Phynosomas* are viviparous, the female giving birth to seven or eight young at a time.

The XENOSAURIDÆ is an intermediate group between the Iguanidæ and the Anguidæ. *Xenosaurus grandis* is of about ten inches in length. The head and legs are covered with close, rounded, smooth tubercles, which on the tail are arranged in regular rings. On the under side, the scutellation is made up of smooth and rather elongated scales, which diminish in size posteriorly. Thus far it has only been captured in Mexico and is probably of nocturnal habits.

The family ZONURIDÆ as now defined contains only three genera, *Zonurus*, *Platysaurus* and *Chamæsaura*, all of which are South African, and resemble each other in having the tongue simple, as well as in several osteological particulars.

Zonurus microlepidotus is represented by several local varieties, all of which prefer the more rocky localities, perpendicular precipices being the favorite haunts of some. They wander about on the narrow shelves in search of insects, or of some particularly warm niche, where they can doze in the sun's rays unmolested. On being disturbed, concealment is quickly found under some rock or in a narrow crevice, where, aided by the prominences on the hinder edge of each temple, they so secure themselves as to make it almost impossible to extricate them. *Z. griseus* is also a very abundant form, and is widely distributed over southern Africa, where there is scarcely a stony knoll or rocky retreat which does not afford habitation for one or more. The colors of the individuals vary exceedingly, no two being similarly ornamented.

Platysaurus has the tail but poorly armed, and in general appearance is much more elegant than the previous genera, which, however, it agrees with in its choice of habitat, and in retreating, on being disturbed, into crevices and under stones, where it is enabled, by its long, hooked claws, to retain a powerful hold. Its food is chiefly composed of insects.

Chamæsaura anguina has an elongated, angular body, covered with lengthened scales and ornamented with longitudinal bands. Though provided with limbs, they are of a most rudimentary character, being extremely small, and, instead of having digits, each ends in a simple point. They are of no use in progression, and are simply organs atrophied by disuse. *C. anguinea* is found in the more moist localities among grass or stones, and in the vicinity of water. Though without feet, it is, by assuming a serpentine movement, able to progress with great rapidity.

The ANGUIDÆ includes a number of both Old and New World lizards, which are characterized by several peculiarities of the bony framework, as well as in having the anterior portion of the tongue retractile.

The genus *Anguis* has the body greatly elongated, serpentine, and terminated by a lengthened tail. No appendages are present, and the shoulder-girdle, sternum, and pelvis are rudimentary. The eyes are provided with movable lids and the ears are concealed by the overlying skin. *A. fragilis*, the orvet or blind worm, inhabits Europe and a portion of Asia, and was considered by Cuvier to be a serpent, so much like these reptiles is it in its general appearance. In England it is very abundantly found in the more retired localities, where it can pursue its prey unmolested, though it is occasionally seen along the roadside, where its bright glossy body and shining black eyes at once attract attention. From a popular mistaken notion, the harmless animal is seldom made a pet of, it being considered poisonous. It has, however, proved to be an extremely interesting animal in captivity, though it is only with the exercise of considerable patience, that it can be made to accustom itself to its

new surroundings, and not break off its tail on the apprehension of danger; a piece of self-mutilation which is often resorted to, in out-door life, as a means of escape. The animal is beautifully colored with red scales edged with white, and ornamented along the sides with stripes of dusky brown. The adults seldom exceed the length of twelve inches.

Though slow and deliberate in its movements, there is no reason for calling this lizard a 'blind-worm.' The eyes are well developed and are indispensable to an animal of insectivorous diet. The young, which are very hardy, are brought forth alive, and to the number of six or eight.

Allied to *Anguis* is the *Ophiodes* of Brazil, an animal having the hind limbs represented by a pair of short, flattened, undivided, and pointed appendages, springing from each side of the abdomen, and with eyes protected by movable lids. The genus *Barisia* is found in Lower California and Mexico. It is peculiar in having no single frontal plate. *B. olivaceus* is dark olive green, with bars of dusky brown, and beneath greenish white. *Gerrhonotus* is represented in the more western portions of the country by several species, of which *G. nobilis*, inhabiting New Mexico and Arizona, is, though of small size, one of the most beautiful. The body is slender and elegant, supported by graceful limbs, and of a clear olive color. It is more or less spotted with black, and crossed, from the occiput to the tail, by nine or ten transverse, brown bands. *G. principis*, the Oregon lizard, has been captured in the Pacific region, though it is rare. *G. multicarinatus*, the many-keeled lizard, is perhaps the most abundant species. It is a slender and graceful animal, inhabiting the Pacific and Lower California regions, and is characterized by having sixteen longitudinal rows of strongly carinated scales extending along the back. The color is yellowish green, irregularly banded with narrow, brownish lines.

We now come to one of the most interesting of American lizards, the *Opheosaurus ventralis*, inhabiting the warmer portions of the United States, east of the Mississippi and south of the Ohio River. It chooses the drier localities, where it often burrows into the soil, spending much of its time underground, and about the roots of old trees. It is said to be quite frequently brought to light by those digging sweet potatoes. Though destitute of feet, this peculiar lizard is able, by its serpentine movements, to retreat, on being disturbed, with considerable swiftness, and is seldom captured without injury; for the tail, the vertebræ of which are but poorly articulated, is so brittle as to break off at the slightest blow. This fragility has given the animal the popular name of 'glass-snake.' In coloring it is, above, of a yellowish green shade, lined with black. Below it is yellow. The snout is long and pointed, the ear-pits large, the eyelids well developed, and each flank is provided with what is ordinarily a deep groove, but which, on the animal's swallowing some large object, appears as a tract of elastic skin, the rigid skin of the body generally being incapable of expansion. The tail is cylindrical and elongate, being about twice the length of the body. The popular belief that the tail, when broken from the body finally becomes attached again, is explained by the fact that a new one soon grows out.

The family Aniellidæ, including the Californian genus *Aniella*, is probably degraded from the Anguidæ. *Aniella* is destitute of limbs. The nasal shield is so bent at its lower edge as to form a part of the labial margin, and inside of it is the labial shield proper. *A. pulchra* is a most graceful and elegant creature, smooth and glossy, and with the upper portions ornamented with narrow, brown, zigzag lines, passing the length of the body.

The HELODERMATIDÆ includes the largest North American lizard, the Gila monster, *Heloderma suspectum*. This animal, whose habitat is New Mexico, Arizona, and the country lying southward, is, because of its poisonous nature, as well as from its large size and peculiar ornamentation, a common object in the larger zoological collections and menageries, where it thrives on eggs, and at times wakes from its ordinary stupor and is quite lively. In its native haunts it attracts attention by its strange coloration, as it is of a deep black, ornamented with irregular blotches of orange, and covered by a thick and rigid coat of small horny tubercles and scales.

Though the more incredulous scientist has questioned the character given this animal by the superstitious Indians and Mexicans, who regard it with the utmost fear, maintaining that it possesses venom of a most virulent nature, a test was recently made by Dr. Shufeldt, which is of considerable interest. He says, in giving an account

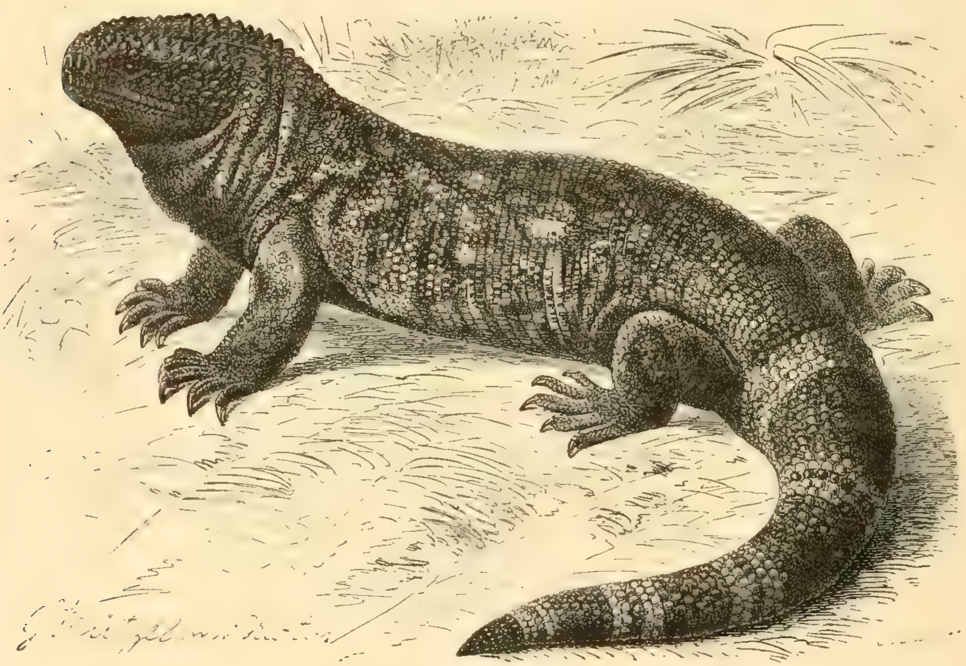


FIG. 246.—*Heloderma horrida*, Gila monster.

of an animal at the National Museum: "It was in capital health and at first I handled it with great care, holding it in my left hand, examining special parts with my right. At the close of this examination I was about to return the fellow to his temporary quarters, when my left hand slipped slightly, and the now highly indignant and irritated Heloderma made a dart forward and seized my right thumb in his mouth, inflicting a severe lacerated wound, sinking the teeth in his upper maxilla to the very bone. He loosed his hold immediately, and I replaced him in his cage, with far greater haste, perhaps, than I removed him from it.

"By suction with my mouth, I drew not a little blood from the wound, but the bleeding soon ceased entirely, to be followed in a few moments by very severe shooting pains up my arm and down the corresponding side. The severity of these pains was so unexpected, that, added to the nervous shock already experienced, no doubt,

and a rapid swelling of the parts that now set in, caused me to become so faint as to fall, and Dr. Gill's study was reached with no little difficulty. The action of the skin was greatly increased, and the perspiration flowed profusely. A small quantity of whiskey was administered. This is about a fair statement of the immediate symptoms; the same night the pain allowed of no rest, although the hand was kept in ice and laudanum, but the swelling was confined to this member alone, not passing beyond the wrist. Next morning this was considerably reduced, and further reduction was assisted by the use of a lead-water wash.

"In a few days the wound healed kindly, and in all probability will leave no scar. All other symptoms subsided without treatment, beyond the wearing, for about forty-eight hours, so much of a kid glove as covered the parts involved.

"After the bite our specimen was dull and sluggish, simulating the torpidity of the venomous serpent after it has inflicted its deadly wound, but it soon resumed its usual action and appearance, crawling in rather an awkward manner about its cage."

Dr. Shufeldt's conclusions, however, that the symptoms were no other than usually follow the bite of an irritated animal, seem to be given a little prematurely. The same reptile was afterward induced to bite the edge of a saucer, into which, during the action, a secretion dribbled. This secretion, which was of a distinctly alkaline nature, in contrast to the serpent-venoms, which are acid, was, in a small quantity, injected into the breast of a healthy pigeon, and produced death in seven minutes. On a second trial a small quantity was injected into the carotid artery of a rabbit, the animal dying in one minute and thirty-five seconds. Different from the action of serpent-poison, which affects the respiratory functions, the poison of Heloderma attacks the heart and the spinal cord. The power of this portion of the nervous system to respond to even powerful electric currents is abruptly annihilated.

The family of water-lizards, the VARANIDÆ, contains some of the largest animals of the order. They are chiefly semi-aquatic, their elongated bodies and compressed tails enabling them to swim with considerable power. Much of their time is spent on shore however, and, though less active than when in the water, they are lively and agile, several species being partly arboreal. All are carnivorous, feeding on different water animals, and on the eggs of birds as well as those of the larger reptiles. Just below each valvular nostril is a cavity of considerable size, from which the animal can obtain a limited supply of air when below the surface, where it often remains for considerable periods of time. Representatives are found in Africa, their true home, and in Asia and Australia. They resemble each other, and are characterized by having the snout produced, conical, and covered with non-imbricate shields; the teeth acute and compressed, and the tongue slender, terminating in a fork, and retractile into a sheath at its base. The scales of the back are small, equalling in size those of the sides, and arranged in cross-rows; those of the belly and tail being square and arranged in bands. The tail is long and generally compressed, and the toes are five in number and provided with strong claws.

The Indian water-lizard, *Varanus dracæna*, sometimes exceeds the length of four feet, the tail being longer than the body. The natives use the flesh for food, the animal being quite abundantly found along the low lands, where dogs are trained to hunt it. It is more or less subterranean in its habits, spending most of its time in its burrows, though during the warmer portions of the day it wanders out, after smaller reptiles and in search of ant-hills. *V. albogularis* inhabits South Africa and sometimes reaches a length of four or five feet. It prefers the more rocky localities, seeking

safety, on being disturbed, in the crevices, where it so clings on to the irregularities of the sides as to make its capture almost an impossibility. If it be dislodged, however, it flies at its enemy with the utmost fury, not infrequently compelling it to retire. The reptile's food consists of frogs, crabs, and small quadrupeds, for which it is often seen lying in wait beside some spring or brook of running water. The superstitious natives, who greatly dread the animal from a mistaken belief that it is poisonous,

FIG. 247. — *Varanus niloticus*, monitor.

noting this semi-aquatic habit, have become possessed of the idea that the animal is sacred, and, if injured, has the power, by way of revenge, of producing drought.

The monitor, *V. niloticus*, has the elongated tail with a double-edged keel above, and the teeth rounded. As its name implies, this animal is an inhabitant of the Nile, in which it spends most of its time, seldom going on shore except to search for crocodile's eggs, of which it destroys large numbers. It is, in fact, a most important animal, as it keeps these furious monsters from multiplying to an undue extent, by waging a constant war against them, not only by breaking open their nests and eating the

Varanus salvator, water monitor, kabaragoya.

eggs, but also by following the young in the water, where it can easily capture them, being a most active swimmer. When full grown, the monitor — called so from the notion that the animal gives an alarm on the approach of any poisonous snake — not infrequently reaches the length of five or six feet. *V. salvator* even grows to a greater length. It is an inhabitant of India, and is also abundantly found in the more marshy localities of the Malayan peninsula, where it is often seen among the branches of trees overhanging some stream or pond, in search of young birds or lizards, and from

FIG. 248. — *Teius teguexim.*

which, on being disturbed, even though it be at a considerable height, it plunges into the water and quickly swims away to its hole under some neighboring bank; from which it is only too often dug out for food by the lower Hindus.

The family XANTUSIIDÆ is closely allied to the Teiidæ, though it differs in having the tongue but slightly incised, and the skull of a different structure. The family includes but a single genus, *Xantusia*, which has a slender, cylindrical body, femoral pores, three folds of skin on the throat, the pupil vertical, and the eye unprotected by lids. A single species, *X. vigilis*, inhabits Lower California.

Of the Teidæ, all the representatives are New World forms, while the related acrodont Lacertidæ are confined to the Old World. The genus *Teius* has five toes on each foot, the femoral pores distinct, and the throat with two cross-folds, between which are the larger six-sided scales. In the young individuals, the teeth are plurodont, pectinate in front, and three-lobed on the sides, but as the animal increases in age the bone of the jaw grows up and around their bases, and the front teeth become more rounded.

T. teguexim, or the variegated-lizard, as it is called by some, in allusion to the disposition of its colors, is of a green shade varied with black, and ornamented with two series of white spots on the upper part of each flank. In some localities it is called the safeguard-lizard, from the attributed habit of giving an alarm on the approach of alligators, in the same way that the monitors of the Nile are said to make known the presence of serpents. It is an animal of considerable size, sometimes reaching the length of five feet, and, being bold and strong, is, when provoked, no ordinary enemy. It inhabits the more retired situations of tropical Brazil, where it finds an abundance of the small reptiles and insects on which it feeds.

Ameiva has the ventral shields broad and smooth; the tongue elongate and sheathed at its base; the teeth compressed, and three lobed, and the feet ending in five toes. Several species inhabit the more tropical portions of the New World. *A. dorsalis*, the ground-lizard, is one of the most abundant reptiles of Jamaica, where it is often seen by the road-side, as it is scratching in the sand, or peering out from behind some fallen leaf. Always restless and active, it sometimes shoots along over the short grass with such rapidity that it seems to fly. It is met with everywhere, not only along byways, but in open pastures and cultivated fields, its beautifully colored body, bright green eyes, and gentle manners rendering it a universal favorite in spite of all prejudices.

Allied to *Ameiva*, but having the tongue free at the base, is *Cnemidophorus*, a genus represented in the United States by a dozen species, the most of which inhabit the Rocky Mountains, though *C. sexlineatus*, the six-lined or striped-lizard, is abundantly found in the southern states as far north as Virginia, and extending west into Mexico. It is a lively little animal, running about on the ground with great swiftness in search of insects, and often in the neighborhood of plantations, where its prey abounds. It is a timid animal, however, seldom wandering far from its retreat, and is more or less crepuscular, being seen, the male and female often in company, towards the close of day. The ordinary length is about ten inches, of which the tail is more than half. The animal is dark brown above, marked with six yellow longitudinal lines, all but two of which disappear on reaching the tail, which is roughened by the carinated scales. Below, the scales are smooth, and of a silvery-blue color.

C. tigris, inhabiting the Pacific slope, Utah, and the country lying south, has four yellowish indistinct stripes along the dorsum, and while the back and upper portions of the legs are covered with only minute scales, those of the lower side of the body and legs, as well as those of the throat, are large and strong. On the tail, which is cylindrical, and two and one half times the length of the body, the scales are of a third character, being longer than broad, arranged in annular rows, and more or less carinated.

The family Amphisbænidæ contains some of the most degraded lacertilians, though they have points of structure which connect them with the previous family.

The snake-like body is unprotected by scales except in the region of the head and throat, and the skin is divided by closely arranged, transverse constrictions, and by more shallow longitudinal furrows into oblong divisions, which give the animals, often assisted by their peculiar color, a mosaic-like appearance. The pectoral girdle is very rudimentary, except in a single genus, and the sternum is never present. The pelvic arch is represented by rudiments, though it never bears appendages. The bones of the skull are firmly articulated together, and the rami of the lower jaw are united in front by an unelastic symphysis. The eyes are small and, like the ears, covered by the integument. The teeth may be either placed along the ridge of the jawbone, acrodont, or along the inside, plurodont.

The genus *Amphisbæna* has the teeth plurodont; two large nasal shields, behind which are two pairs of frontals; the head flat with a rounded snout; and in front of the vent a transverse row of so-called pre-anal pores. The generic name has been given because of a popular notion that the animal, which can progress in either way, is provided with a head at each end, the short rounded tail resembling the head in general outline. The sooty Amphisbæna, *A. fuliginosa*, is the most common species,

FIG. 249. — *Amphisbæna alba.*

and is found throughout the warmer portions of South America, where it hides in the ground, through which, like the earthworm, it tunnels its way in search of larvæ. The young of ants form the chief element of its diet.

Rhineura floridana is an allied form. This animal, the only native member of the family, has been many times captured in Florida, where, from its habit of leaving its subterranean home and coming to the surface after thunder showers, it has received the name of 'thunder-worm.' It is of a dirty white color, on the upper surface of the head becoming yellowish.

Also of subterranean habits, though differing from the other members of the family in having a pair of small limbs terminated by five toes, is *Chirotes*, a genus inhabiting Mexico and Lower California. The head is no larger than the rest of the the body, the teeth are conical and slightly recurved, and the tongue, like that of the woodpecker, is tipped with horn. On the abdomen is a row of pores resembling those of *Amphisbæna.*

We now come to an Old World family, the LACERTIDÆ, which is represented by several genera.

Pseudopus is found in Europe and southern Asia. It has the body long and snake-

like, the quadrangular scales arranged in transverse series, and the limbs absent or represented by a single pair of appendages, unprovided with toes and placed at the posterior portion of the abdomen. *P. pallasi*, a timid animal inhabiting the more central portions of Europe and Asia, seldom wanders far from its retreat, to which it quickly retires on the slightest apprehension of danger. It is said to be especially fond of dark, wooded glens, where it can find the nests of smaller birds, feeding to a considerable extent on their young. In its marking it is dull brown, a shade which well harmonizes with its usual surroundings. *P. gracilis*, the Khasya glass-snake, is a closely allied form inhabiting the Khasya Hills of India, but differs in being unprovided with even the rudiments of limbs. Like other lizards having a longitudinal fold of skin running along the sides, the scaly covering of the back and abdomen is so rigid that it prevents the general distention of the body so characteristic of serpents

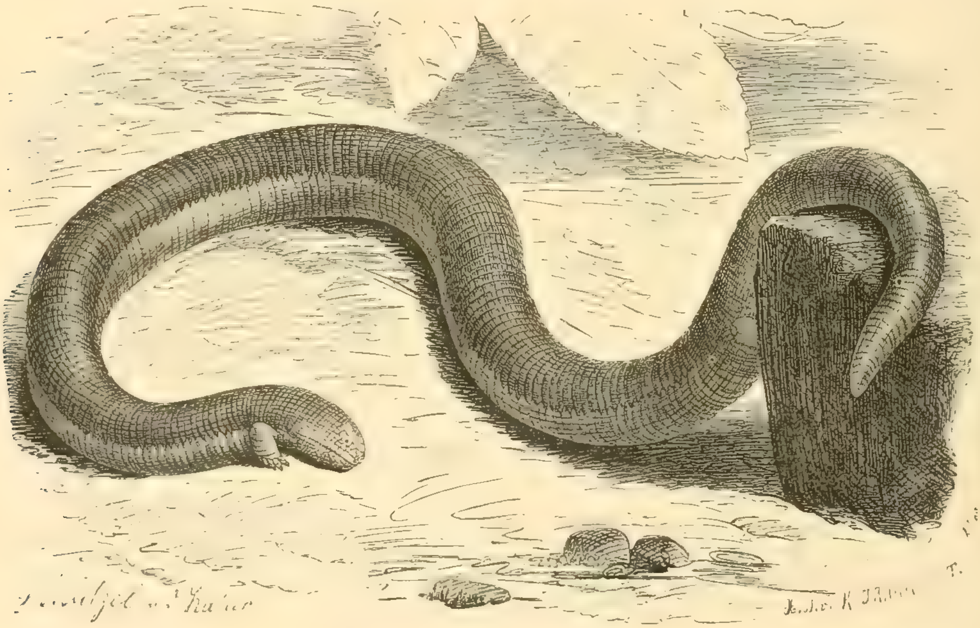


FIG. 250. — *Chirotes canaliculatus.*

and some lizards; food, however, of considerable size is allowed to enter the body through the elasticity of these lateral folds, extensibility being here limited to a special area, like that of *Opheosaurus.*

The genus *Lacerta* is abundantly found in the warmer portions of the Old World. These lizards are diurnal in their habits, the eyes being provided with connivant lids; and they run about over rocks and prostrate logs, seldom or never attempting to lead an arboreal life. The scales are non-imbricate, simply appressed, and the limbs are four in number and well developed.

L. agilis is a most familiar object of the country in England, as well as on the continent, being popularly known as the gray or sand-lizard. In the warmer portions of Europe these inoffensive creatures are very abundant; and, though of fair size, being sometimes ten inches in length, they are extremely agile, their movements being so rapid that the eye can with difficulty follow them, as they scamper away over the

ruins and debris. They are said to live in pairs; the father and mother, while having considerable mutual regard, assuming a most indulgent disposition towards their often wayward offspring, leading them to situations where they may be warmed into activity by the sun, or sheltering them from the cold. All, at the beginning of winter, dig for themselves little cavities in the earth, in which they coil up and sleep until the approach of spring. *L. viridis*, the green-lizard, is found in Jersey and localities around the Mediterranean; a most beautiful animal, inquisitive, confiding, sprightly, and courageous, it is always watched with interest. *L. muralis* is abundant about the ruins of southern Europe and on the islands of Sardinia and Malta.

Zootoca vivipara is peculiar in that the eggs are hatched while in the oviduct.

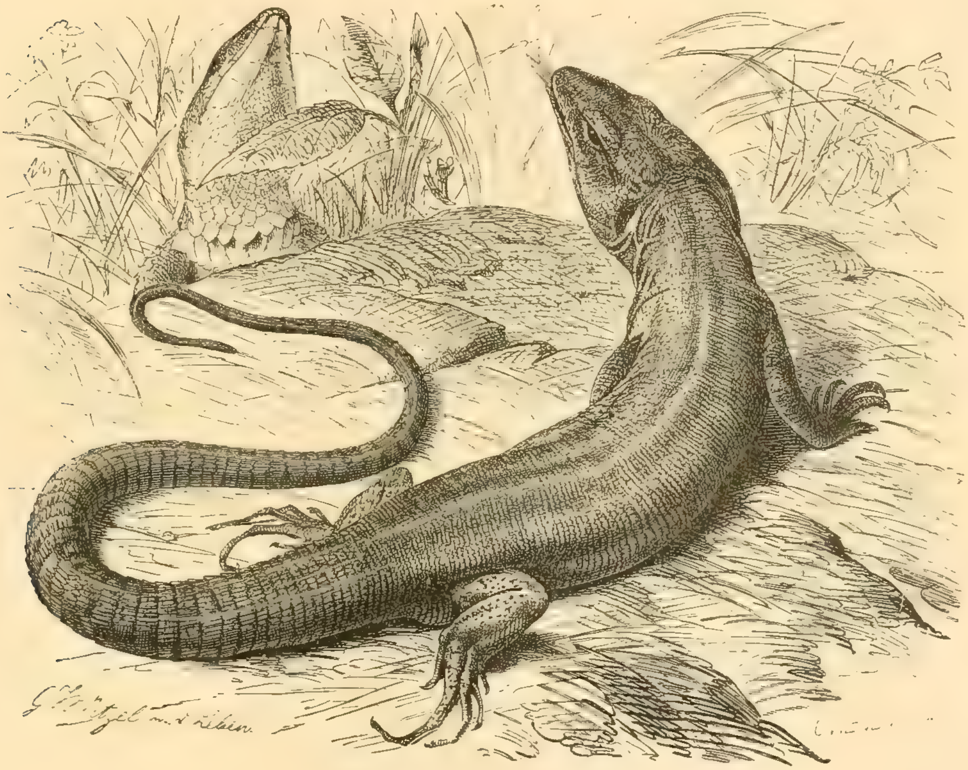


FIG. 251. — *Lacerta viridis*, green-lizard.

It is a very abundant animal throughout England, being particularly fond of heaths and warm banks, where the female is said to lie in the sun for some time before the young are born, that the eggs may be incubated by its warm rays. The scaly-lizard, as this animal is popularly known, is very active; and, being quite sharp-sighted, its capture is anything but an ordinary occurrence.

Trachysaurus rugosus is one of the most peculiar creations of nature. The head is short, pyramidiform, and distinct from the short, thick neck. The trunk is elongated and bulky, and the tail is short, large, flat, and rounded at the end, and so abbreviated as to appear at first sight to be a mere remnant, the rest seeming to be lost by some mishap. The short, thick legs, terminated by toes which are armed with

stout nails, are too small to allow the animal any very rapid movements, the chief source of protection being in the hard, thick tuberculate shields which cover the entire upper side of the body, though below they become thin and smooth. About this strange animal's habits but little is known. It has been captured in western Australia.

The family Gerrhosauridæ includes but a single genus. *Gerrhosaurus flavigularis* is a slender lizard, inhabiting South Africa, of about twelve inches in length, and colored above with yellowish-brown, striped and banded with lighter and darker shades. Localities covered with a thick growth of underwood seem to be the most often chosen, the animals, on apprehending danger, concealing themselves by burrowing under the dead leaves or loose earth. Specimens are distributed over a wide area,

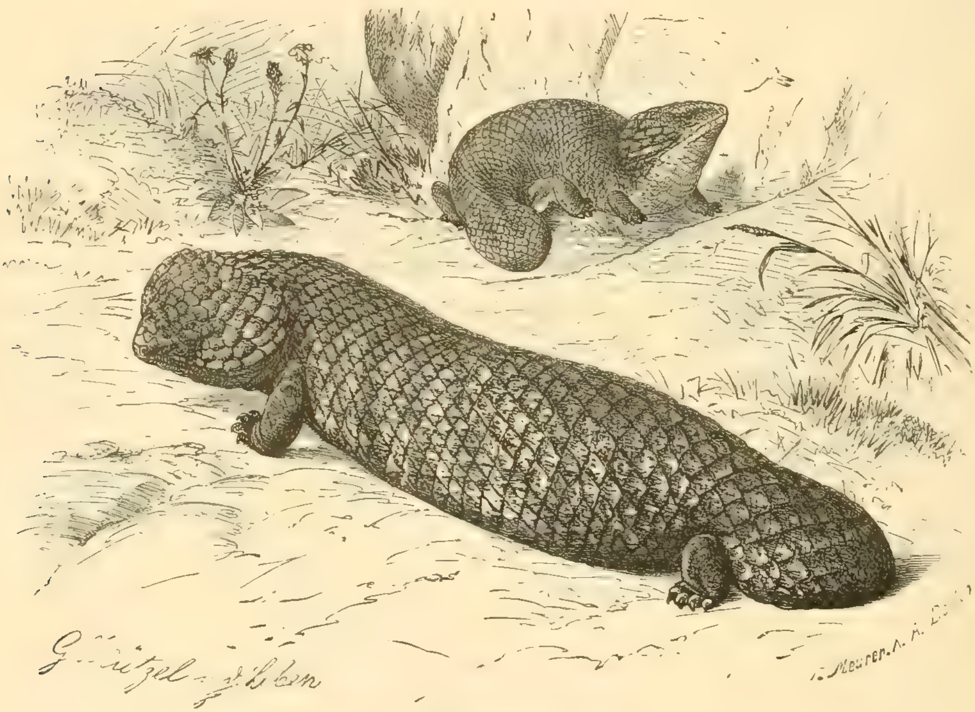


Fig. 252. — *Trachysaurus rugosus.*

from Cape Colony as far north as the Tropic of Capricorn. *G. bibroni* inhabits the shaded ravines of the Orange River, while *G. typicus* prefers the dry plains, over the sand of which they scamper with most extraordinary rapidity, it being almost impossible for the eye to follow them in their flight. They are also active burrowers, and, on being disturbed, often conceal themselves in the loose sand, though only to a moderate depth.

Scincidæ includes a large number of terrestrial lizards inhabiting the more tropical countries generally, and protected by a covering of smooth bony plates, which, on the crown, are regularly arranged, like those of serpents. Skinks are found secreted under old logs, bark, and dead leaves, or in shallow burrows in loose earth. They are oviparous, and the eggs, to the number of ten or a dozen, are hid away in those situations.

The genus *Cyclodus* has the scales thick and round, the body with four short, five-toed extremities, and terminated by a rounded tail. The lower eyelids are scaled. *C. gigas*, of Australia, is one of the largest members of the sub-order.

Scincus has the body elongated and provided with four limbs, each bearing five-fringed digits; the head elongated and flat; palatine teeth present; openings of the nostrils in the middle of the triangular supranasal shield, and the under eyelids covered with scales. Though once made to include several species, there is now but a single representative. The common or officinal-skink, *S. officinalis*, is a native of south Africa, and inhabits the more sandy localities, where, by means of its peculiarly shaped feet, it so quickly buries itself beneath the surface, on being surprised, that it seems to glide into an already formed burrow. Though the limbs are well developed, the animal is only an ordinary walker, seldom wandering from its chosen locality, and then only in search of small insects. To bask, half asleep and undisturbed, in the

FIG. 253. — *Scincus officinalis*, common skink.

sun, seems to be its chief delight, and, when thus indulging itself, is often quite indifferent as to what may be going on around it. It has been named 'officinal' because of the high esteem in which it was held by the medical quacks of the middle ages; its body, dried and reduced to a powder, being thought to possess the most wonderful virtues, and was prescribed as a specific for nearly every disease of the human body.

The genus *Seps* has the body much more elongated than *Scincus*, the limbs are terminated by only three toes, and the lower eyelids are transparent. The legs are very weak, and are used but little as organs of locomotion, the animal being more snake-like in its movements. Its teeth are small and simple, on the jaws only, and adapted to seizing and retaining small insects, worms, slugs, and the like. *S. tridactylus* is of a gray color, striped with four longitudinal rows of appressed brown dots. To this harmless animal, which inhabits the regions bordering on the Mediterranean, have the ancients given a most frightful character. They maintained, and the belief

is still current in some localities, that the seps would enter the shelters of cattle, and, while these animals were asleep, would inocculate them with a most corrupting poison. This attributed habit has given them a name which signifies, in the Greek, corruption. *S. chalcides* inhabits Dalmatia.

Acontias has the legs entirely absent, the upper eyelid rudimentary, and no abdominal pores. The type species, *A. meleagris*, is a south African animal, where its habits are strikingly like those of the European blind-worm. It is possible that a second species of this genus inhabits Ceylon. *Nessia* is an allied genus, having four rudimentary legs, and represented by two species; *N. burtonii*, having the feet divided into three minute toes, and *N. monodactylus*, having the toes undifferentiated. These small animals resemble the rhinophid snakes in their habits and general mode of life, though their habitat is much more restricted, the genus having been found only on the island of Ceylon.

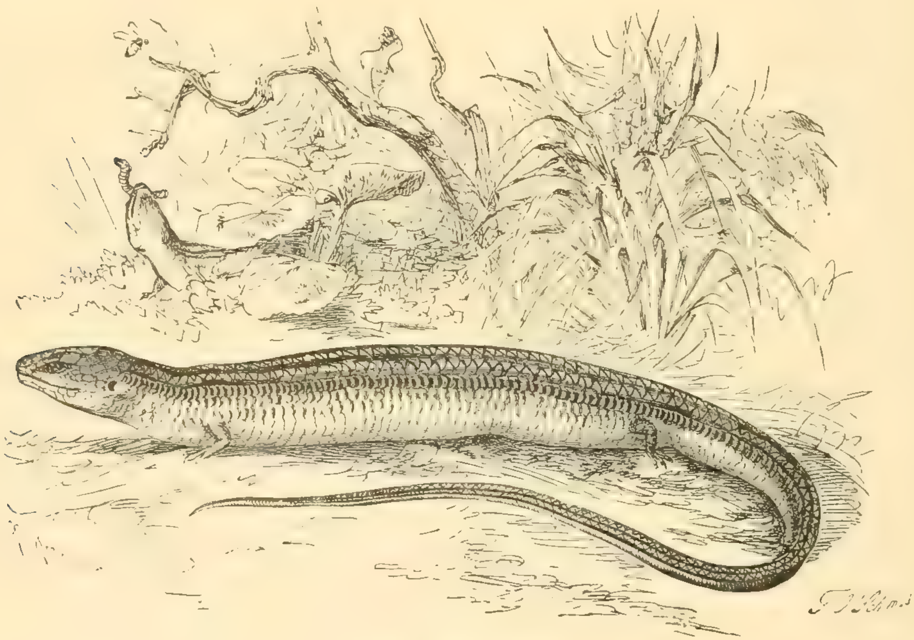


FIG. 254. — *Seps chalcides.*

The ground-lizard of the southern states (*Oligosoma laterale*) is in its habitat a most familiar animal. While wandering through the woods of Louisiana, the noise these little animals made as they scampered away was truly astounding. Not being acquainted with them, my first impression was that I had disturbed a colony of beetles; but my mistake was soon apparent, for these reptiles were by far too abundant for all, on being surprised, to find immediate shelter. If captured, — a by no means easy task, — they make no violent effort to escape, but, with a most droll expression, they eye their captor; soon winning his confidence, but betraying it at the most unexpected moment, for with a quick struggle the tail is dropped off, and, before one has recovered from his surprise, no lizard is to be seen, the tail only remaining, which for some little time twists about with as much vigor as when attached to its owner.

This self-mutilation of the lizard offers a remarkable instance of protection. It

will be seen that the animal, being comparatively slow of foot, cannot ordinarily seek safety in flight, and having no organs of defence, it, on being attacked, breaks off a portion of its tail, which, still alive and twisting about by reflex action, attracts the attention of the enemy, and the lizard, unencumbered and unnoticed, glides into some crevice, and is safe. The muscles of the tail are so arranged that they, by contraction, close over the place of amputation, and bleeding is prevented. From the thus blunted appendage a new rudiment soon appears, which, in a short time, replaces the lost part. It is stated, however, that the new growth differs from the original in having the vertebræ represented by an unsegmented cartilaginous rod.

The ground-lizard is, above, of a dark, shining, brown color, well harmonizing with the shades of soil, dead wood, and roots on which it abides. Along each side, running from the eye above the insertion of the legs, is a black line, below which the coloring lightens, the free skin of the throat being pink, shading into yellow along the abdomen, and passing into a beautiful blue further back. Its more restricted habitat is in the thick forests of oak and hickory of the Carolinas, Georgia, Florida, and the gulf states.

The genus *Eumeces* is very abundantly distributed over the warmer portions of the globe, the United States alone having over a dozen species, and is characterized by having the scales thin, smooth, and polished; the tail fusiform and smooth; the nostrils piercing a single plate; palatine teeth absent, the limbs well developed, and each provided with five toes. Some species have the lower lids transparent.

Eumeces fasciatus, the blue-tailed skink, is the best known of the genus. Not only is it abundantly found over a large area throughout the more central, southern and eastern portions of our country, but it is a wanderer, coming to light not infrequently in remote situations. In coloring it is, above, of a deep, glossy green, ornamented with fine, narrow, yellow, longitudinal lines passing, on the tail, into a beautiful ultramarine, a shade which is also adopted by the lines. Below, the animal is of polished, pearly white. The total length is between eight and nine inches.

The blue-tail is a lizard which secretes itself between the loose bark of some tree, and there lies in wait for small Coleoptera and grubs. Though it is a good climber, it does not habitually ascend trees, but may wander unrestrictedly through the dark interior galleries of those monarchs of past ages which are occasionally met with in the midst of wild southern forests. During early morning, or dark days, when partially chilled, the animal, though at other times so active, is indifferent and helpless, often two or three individuals being found together, buried in the rotten wood at the base of a stump, or in a hollow below some prostrate log.

A near relative, the Bermuda skink, *E. longirostris*, is the only living representative of the order in this isolated group, though it is possible that at some early date there existed larger species, like those of the Galapagos. Captain John Smith, in speaking of these islands in 1624, says, "Lizards there were many and very large, but now none, and it is said they were destroyed by the Cat." A still earlier writer, however, Rev. Lewis Hughes, in 1614, says, "Here is no kind of beast but hogges and cattes and they but in one or two places which we thought to come at first by means of shippe-wracke. The hogges were manie, but are now brought to a small number."

In enjoying the sunshine, and in making a quick retreat, on being disturbed, as well as in several other peculiarities of habit, the Bermuda skink resembles its better known brothers of the continent.

E. skiltonianum, Skilton's skink, inhabits the Pacific region, and has the body greatly elongated, the tail, which is more subquadrangular than conical, being about twice the length of the body. The limbs are small, and the scales, though elsewhere smooth, on the back and tail present four or more longitudinal furrows or stripes. *E. anthracinus* is found in the more mountainous regions from Pennsylvania to Texas. *E. egregius* and *onocrepis* inhabit Florida. In the more southwestern territories are several other species. The eggs of this genus are laid, to the number of ten or a dozen, under leaves, stones, or the bark of trees.

The family ANELYTROPIDÆ includes a small number of degraded skinks. *Typhline* has no limbs, and the pre-anal shield large and single. The eyes can be faintly discerned through the covering of skin. Specimens have been taken at the Cape of Good Hope. *Feylinia* is also unprovided with limbs, but has the pre-anal scales numerous. It inhabits the coast of Africa in the neighborhood of Angora.

This family includes, under the head of DIBAMIDÆ, a still more degraded genus, *Dibamus*, which has none of the osteological peculiarities which characterize the previous families. The posterior limbs only are represented, and these by mere folds of skin. The pre-anal scales are undifferentiated. Its home is New Guinea.

The members of the highest family, the CHAMÆLEONTIDÆ, are all natives of the Old World, and are characterized by having the tongue worm-like, club-shaped, in front, and very exsertile. But a single genus, the acrodont *Chameleo*, is represented.

The chameleons have the large and angular head covered with small, flat shields; the deep and compressed body with shagreen-like skin, and the tail, characteristic, long and prehensile. The eyes are large and globular, and each can be directed towards an object of its own: the eyelids are circular and pierced by a central hole; the tympanum is hidden, and the limbs, which are perhaps the most specialized organs of a highly specialized animal, are capable of supporting the body, and terminated by feet, which are converted into grasping hands by having the five toes arranged by their union as far as the claws in two opposing groups. With the strong grasp of their feet and with the assistance of the prehensile tail, it is almost impossible to shake them off the branch on which they may be slowly feeling their way. On the ground or in the water they are almost helpless. The eggs, protected by a calcareous shell, are deposited, to the number of ten or twelve, under decaying leaves.

The singular power of changing the color of skin is not alone possessed by the members of this family, nearly all of the lacertilians having it to a more or less degree. The phenomenon is brought about by there being two layers of pigment cells underlying the transparent epidermis, the lower and darker, at the will of the animal, or stimulated by surrounding objects, predominating over and through the more superficial and lighter layer. Though the proper home of the chameleons is Africa, where there are several species, they are found along the northern shores of the Mediterranean, in Asia, and on the island of Madagascar.

ORDER IV. — CHELONIA.

The members of this order present less variation in form than do those of any other of the class. The body is invariably short and stout, and is, in all the known forms, protected from above and below by a more or less bony investment, developed ordinarily, directly from the osseous framework; though some forms may have this

Chamaleo vulgaris, chameleon.

armature produced by a secondary growth, the hardening of certain portions of the dermal covering. In all cases the head, tail, and limbs are capable of being protruded from between the margins of the thus formed plates, and may be modified for special habits; as broad and fin-like for marine, simply webbed for inland aquatic, or short and stump-like for terrestrial life. Four limbs are always present; and the jaws are unprovided with teeth proper, being simply encased in horn, like those of birds.

As to the shield-like covering, it is of considerable importance to the systematic zoologist, often presenting most distinctive characters. By reference to the illustration it will be seen to consist of two portions, the dorsal, or carapax, and the ventral, or plastron, and to be divided into geometrically shaped portions, or plates of a horny nature, which in no way follow the outline of the underlying bones. These plates are

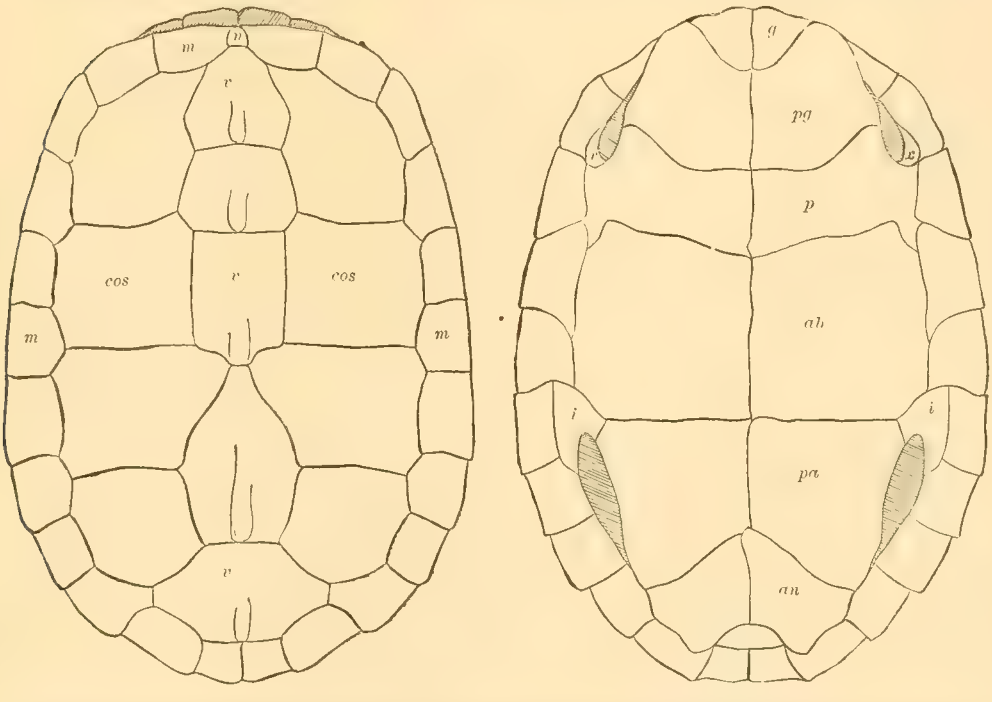


FIG. 255. — Diagram illustrating the dorsal and ventral plates of a turtle; *ab*, abdominal; *an*, anal; *c*, caudal; *cos*, costal; *g*, gular; *i*, inguinal; *m*, marginal; *n*, nuchal; *p*, pectoral; *pa*, pre-anal; *pg*, post-gular; *v*, vertebral; *x*, axillary.

of considerable commercial value in some turtles (*Chelonia*) as they are the 'tortoise-shell' of commerce.

From the rigid portion of the vertebral column, the expanded processes of which, together with the suturally united ribs, form the carapax, the flexible neck projects, and is capable of being more or less completely retracted into the cavity of the shell. The eight vertebræ of which it consists are entirely destitute of ribs. Posteriorly, the sacral portion of the column is bent down, free from the carapax, and terminated by a flexible tail, which is, on the occasion of danger, not withdrawn under the shield, but simply bent round against the side of the body.

The bones of the head are firmly united to each other, the skull resembling that of birds, though the cranial capsule is considerably less in size. The orbits are sepa-

rated from each other by a bony septum. The internal ear is well developed, and the nares open into the cavity of the pharynx, behind the palatine plate.

The sight of most turtles is very keen, and they are generally watchful; though the marine forms are often captured while apparently asleep, their heads resting on some floating piece of timber. They are also not unfrequently rendered partially blind from the stings of the Portuguese man-of-war, *Physalia*, a cœlenterate of which they are very fond. The eyes are capable of being protected by not only the ordinary upper and under lid, but also by a third, like that of birds, a lateral nictitating membrane. Hearing in some forms is acute; the fact that many, if not all, are

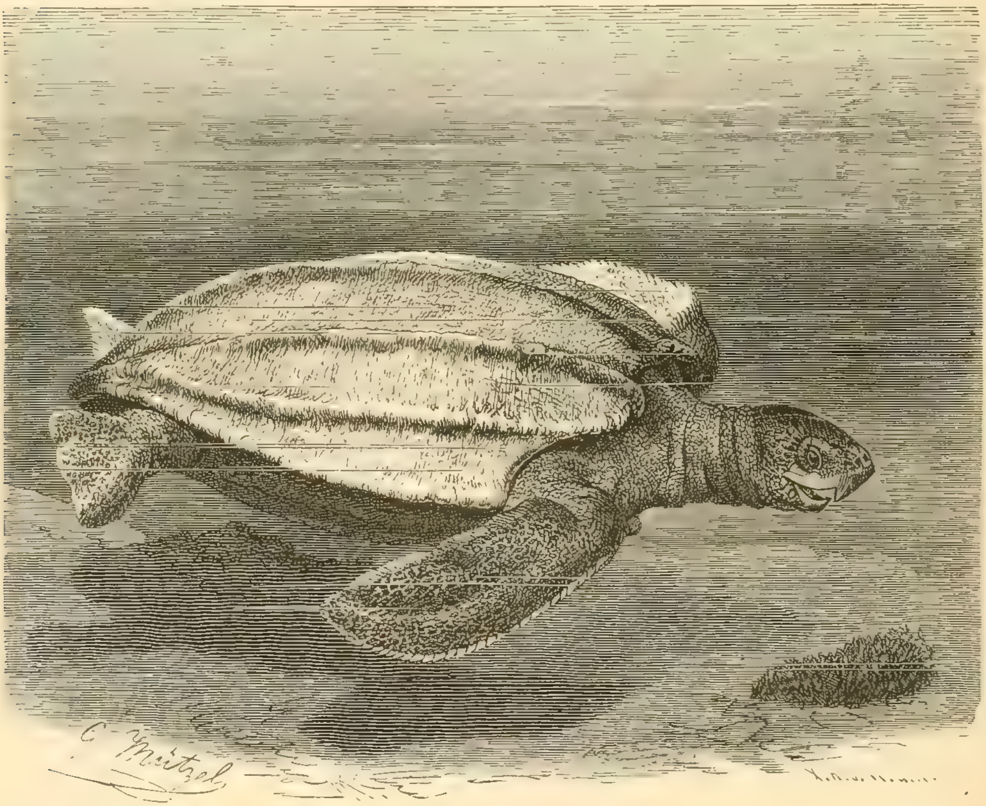


FIG. 256. — *Sphargis coriacea*, leather-back turtle.

musical, argues that their organs of hearing are well developed. The tympanum is at the side of the head, and, like that of the frogs, is unprotected by either valves or cavity. The senses of smell and taste, allied to each other, are but poorly developed.

The circulatory, digestive, and reproductive organs generally resemble those of the lizards proper, though the Crocodilia are anticipated, and the birds to some extent foreshadowed. Respiration is effected by the swallowing of air, the rigid carapax and plastron effectually preventing the expansion of the chest. All turtles are oviparous.

While some of the families of the order of which we are now to treat contain genera which may be enumerated by tens, and species by hundreds, the more embryonic

and introductory family SPHARGIDÆ contains but a single genus, which is represented by a single species.

As will be seen from the illustration, *Sphargis coriacea*, the trunk-back or leathery turtle, is of a depressed top-shape, with the digits not separate, and those of the fore limbs greatly elongated. The back differs from that of all other living turtles in presenting no evidence of its costal origin, and the skin of the exposed portions of the body is unprotected by scales. The animal is of most gigantic size, exceeding that of any other member of the order; specimens weighing over a thousand pounds being not unfrequently captured. Though an animal of the widest distribution, it being found not only through the temperate portions of the Atlantic, but even of the Pacific and Indian oceans and the Mediterranean Sea, its habits are but little known, as it is in no one locality sufficiently abundant to be profitably studied. An interesting account, however, is given by an English officer of a female captured in India.

"She was captured February 1, 1862, near the mouth of the Yé River, on the sandy beach of which she had deposited about a hundred eggs, when she was surprised by a number of Burmese fishermen who had been lying in ambush near the spot (a favorite resort of the common turtle, *Chelonia virgata*), and after a desperate struggle was secured. Her entire length was six feet two and a half inches.

"The strength, aided of course by the enormous weight, of the animal was such that she dragged six men, endeavoring to stop her, down the slope of the beach, almost into the sea, when she was overpowered by increased numbers, lashed to some strong poles, and brought into the village by ten to twelve men at a time.

"The eggs were spherical, of $1\frac{5}{8}$ inches diameter, and were as palatable as those of the river tortoise are nauseous. Besides those the animal had laid in the sand, there must have been upwards of a thousand in her ovaria, in all stages of maturity. The flesh was dark and coarse, and very few of the crowds of Burmans assembled at Yé to see the animal would eat any of it."

In 1880 a large leather-back was captured in a mackerel net off Cape Ann. It was brought to the Summer Laboratory of the Boston Society of Natural History at Annisquam, and from some of its flesh a soup was made, which all who partook agreed was as good as that from the green-turtle.

The family PROTOSTEGIDÆ has been established to provide for an enormous sea-turtle, once inhabiting the bays of the western inland seas of geological times, and at present known from fragmentary fossils.

This turtle, described as *Protostega gigas*, is characterized by having the protecting shield not formed by the expansion of the ribs into a bony roof or plastron, but by the development in the skin of large plates, having no sutural connection either with each other or with the underlying ribs. Such fragments as have been found show that the fore limbs must have been elongated and flat, like those of the sea-turtles of to-day, while several other peculiarities, with this, make it quite likely that the animal's affinities are with *Sphargis*, one of the most ancient of existing turtles.

The family CHELONIIDÆ includes four genera of marine turtles, all of which are found along the coast of the United States. They resemble each other in having the feet compressed and fin-shaped, and, as well as the neck and head, too massive to be retracted beneath the shell. The carapax is so broad and flat that when the animals are placed upon their backs, they are helpless, and it is never osseously united with the plastron. The head is large and rounded, and covered with bony shields. The animals are strong and powerful, of enormous size, and frequently lead for months at

a time a pelagic life, repairing to the shore only to deposit their eggs, which are buried, often to the number of two hundred or more, in the sand. Sea-turtles are of considerable value as food, though the East Indian species are not as generally used, because of the poisonous qualities supposed to be acquired at certain seasons of the year. Extinct members of the family have been found in the tertiary deposits.

The genus *Thalassochelys* has fifteen vertebral and costal shields, which are thin and not imbricate. The American loggerhead, *T. caouana*, is a carnivorous form, living on fishes, crustaceans, possibly sponges, and especially on the soft parts, which they obtain by nipping off the spire, of the large conches so abundant in the more

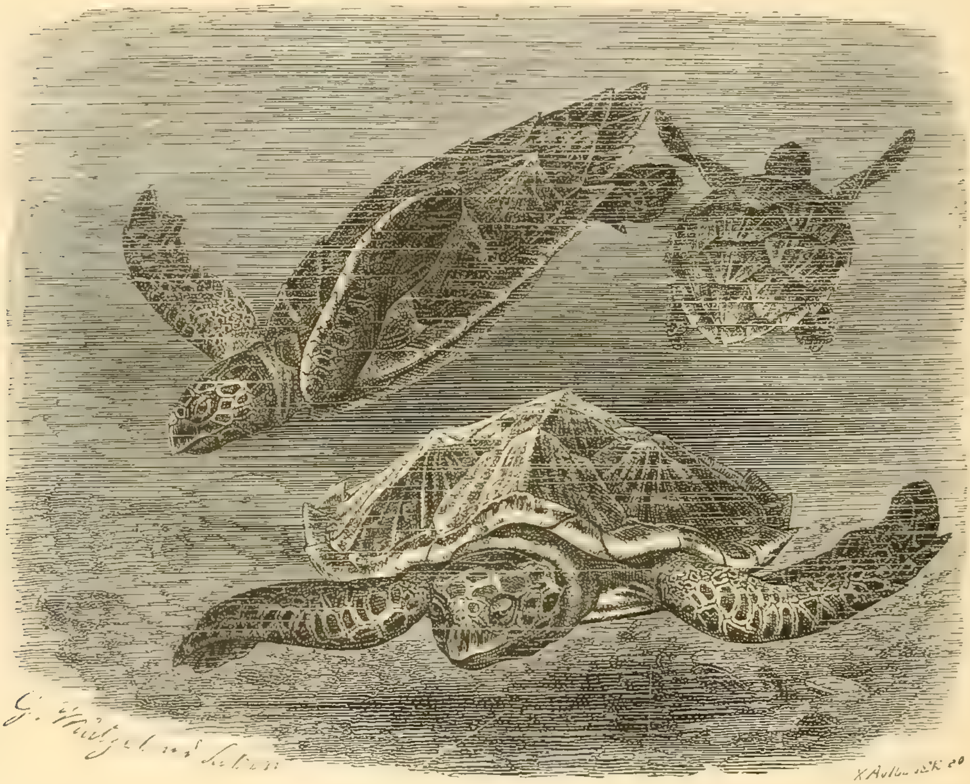


FIG. 257.—*Eretmochelys imbricata*, hawk's-bill turtle, caret.

southern waters. It is found along the Atlantic coast, from Brazil to Massachusetts, and is not infrequently captured about the southern shores of Europe and in the Mediterranean. During the months of April, May, and June, their breeding season, they are to be seen about the low, sandy islands of the southern and gulf states, when they are much less suspicious than usual, allowing boats to approach quite near to them, and are hence captured at this time in large numbers. At night the females approach the shore, and dispose of their eggs, which, as well as those of the green-turtle, are eagerly sought after by fishermen. For food, the flesh of this species is inferior, being rank and tough. Instances of the loggerhead weighing over 450 pounds are rare, much less in weight, it will be seen, than the green-turtle. An Indian Ocean

species, *T. olivacea*, has but a single claw on each foot. Its flesh is only eaten by the Chinese.

Of the genus *Eretmochelys* but two species are known, both of which are found along the coast of the United States; *E. imbricata* from Brazil to the Carolinas, and *E. squamata*, along the Pacific coast. They are at once distinguished from the other sea-turtles, because of their small size, and in that the thirteen vertebral and costal shields are imbricate.

The hawk-bill or caret, *E. imbricata*, is a carnivorous animal, living on the same food as the loggerhead, but of a much more ferocious nature, snapping at whatever may excite its rage, and in captivity using its strong jaws with no other apparent reason than to pick up a quarrel. From an economic standpoint, the animal is of considerable value, because of its so-called 'tortoise-shell,' the horny imbricate plates covering the bony framework, which are in this genus very thick, and of such a nature that by the proper application of heat they cleave away from the underlying bone and can be warped or moulded after being immersed in hot water. It is of good quality only when taken from the older individuals, and varies much in weight. The caret of the Pacific is said to be sometimes roasted alive until the plates start from its back; these are torn off, and the animal is then allowed to escape. This cruel expedient is resorted to because the shell is supposed by the ignorant fishermen to lose much of its brilliancy if the animal has been dead for any length of time. The finest tortoise-shell, however, — that taken on the Celebes, — is removed by the use of boiling water after the animals have been previously killed. The flesh of the hawk-bills is inferior, though their eggs are sweet and palatable.

The genus *Chelonia*, having thirteen large appressed plates on the back, is represented by an Atlantic and a Pacific species.

The common green-turtle, *C. mydas*, is found along the Atlantic coast, from southern Brazil to Cape Hatteras, and is not infrequently seen in the Gulf Stream, and even further north, a few specimens having been taken east of Long Island. This is the most valuable of the turtles for food, and sometimes reaches the enormous weight of eight hundred and fifty pounds. It is a vegetarian, feeding on the roots of *Zostera*, the plant known in New England as eel-grass, though further south it is called turtle-grass. When thus grazing, the roots only being acceptable food, the tops are allowed to rise to the surface, where they indicate to the 'turtler' the animal's whereabouts, who, armed with a strong steel barb attached to a rope, and loosely fitted to the end of a pole, carefully rows up to the unsuspecting animal, with a strong thrust plunges the barb through its shell, withdraws the pole, and grasping the rope, now firmly attached to the turtle's back, lifts the animal to the surface, and, with assistance, turns it into the boat, where it is rendered helpless by being thrown on its back and by having its flippers tied. It is not immediately killed, but is placed in a 'crawl,' or turtle pen, where it is bathed by the tide, to wait with other unfortunates the departure of some vessel for the northern markets. The war of extermination is not waged against the adults alone, nor only in their proper element. Early in summer the females repair to the low, sandy, uninhabited islands of the Gulf of Mexico or the Caribbean Sea. At night, if there seems no ground for suspicion, one crawls some little distance up on the sand, and, finding a satisfactory place, at once begins to dig a hollow, in which are deposited from seventy-five to two hundred spherical eggs of about the bulk of those of a hen. These are carefully covered over, and the animal retreats to the water. The turtler, on going his rounds the following morning, notes the trampled

sand, and, by probing with a slender stick, finds the exact position of the eggs. Experience has taught him that in just fourteen or fifteen days the turtle will again return to this same locality to deposit, in a new hollow, a second, third, fourth, or even a fifth lot of eggs, and, so, stationing himself on watch, he surprises the unsuspecting animal as she leaves the water, by means of a pole turns her on her back, and thus leaves her until means are found for carrying her to the crawl.

If the eggs are not discovered, in about six or eight weeks, incubated by the sun, they hatch, and the young scramble towards the water, on the way to which large numbers are killed by birds, and during the first few weeks of their marine life, their shell being comparatively soft, they are destroyed in large numbers by sharks and other predatory fishes. The flesh of the Pacific form, though at certain seasons of the year unhealthful, is said to rival the Atlantic in flavor. The eggs are in great demand, being of particularly rich flavor and are collected in large numbers by the natives of the East Indies. They are only of about an inch in diameter, and are said to keep fresh for a considerable time.

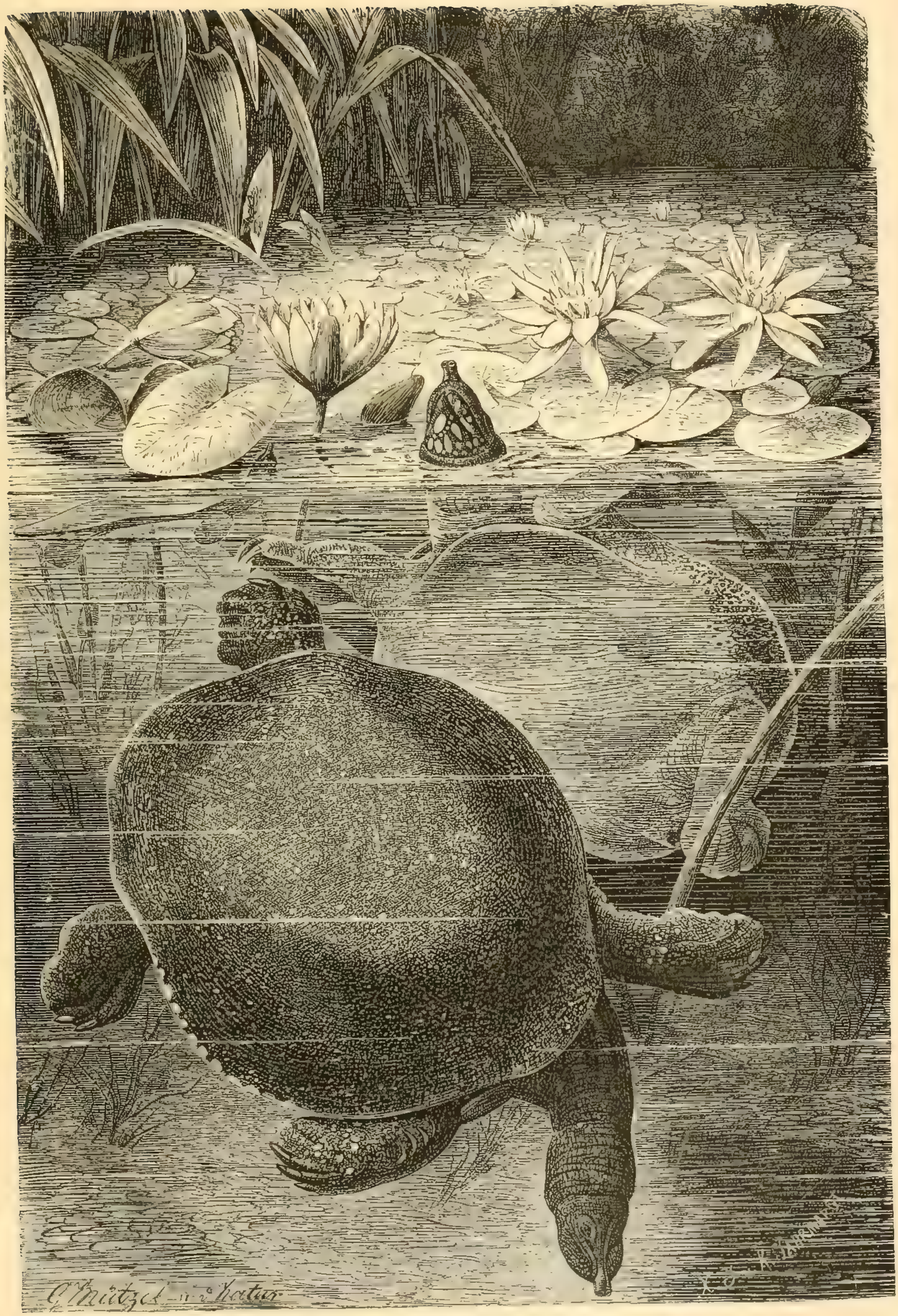
In concluding with the Cheloniidæ a singular fact may be mentioned. The loggerhead and green-turtles not infrequently interbreed, and the offspring, known to the fishermen as the 'bastard-turtle,' has been described as *Colpochelys kempii*.

The family PROPLEURIDÆ is represented by the extinct genus *Osteophygis*, the largest species of which are from the cretaceous deposit of New Jersey. The family is interesting in that its representatives have peculiarities of structure which correspond on the one hand with the sea-turtles, and on the other with the fresh-water Trionychidæ.

The family TRIONYCHIDÆ is of particular interest, and is represented by several living as well as fossil forms. The soft-shelled turtles, as the members of this family are called, have the body greatly depressed, sub-circular in outline, and covered with soft skin. The feet are formed for swimming; the toes distinct, strongly webbed, and terminated by three claws. They are carnivorous animals and lie in wait, half buried in the mud of the warm, shallow pond-holes which they inhabit, their long neck and head swaying to and fro in the water with a serpentine motion and occasionally projecting towards the surface, where the elongated nostrils are protruded above, and a fresh supply of air is taken in. In ploughing through the mud they often meet with fresh-water mussels, of which they are particularly fond. They are active swimmers and purely aquatic, leaving the water only when compelled to. The eggs, the shells of which are hard and calcareous, are deposited but a few feet on shore, the young easily finding their native element. On the pond in which they live drying up, retreat is found, in company with eels and siluroid fishes in the underlying mud, where they remain until the period of drought is over. In confinement they are active and aggressive, though they feed readily, eating vegetable as well as animal food.

Amyda mutica is the smallest of the American Trionychidæ and inhabits the valley of the middle and northern tributaries of the Mississippi as well as the St. Lawrence rivers. It is distinguished from the members of the succeeding genus in having no tubercles on the carapax. A large specimen, measuring twelve inches from the front to the hind margin of the shell, contained in its alimentary tract fragments of larval insects.

Aspidonectes ferox was described as early as 1771 and is popularly known as the soft-shelled turtle. Its habitat is more southern than that of the previous form, being



Aspidonectes ferox, soft-shelled turtle.

found only in those rivers which empty into the Mexican Gulf. It is said to be in its natural state a most voracious animal, almost constantly remaining in the water, and being a most active swimmer, easily capturing fish and reptiles, the young alligators contributing a large share towards its support. Though the ordinary hiding-place is in some hole of the bank or under some projecting log, the soft-shelled turtle is known to not infrequently leave the water and completely bury its body in the mud, keeping up a communication with the outside world by means of its long neck and head, which is ever and anon thrust out of a small breathing-hole which is left open. They are also, during warm summer days, seen, like other turtles, upon protruding logs or rocks, basking and apparently asleep, though a slight disturbance in their neighborhood will start them into the water. This gregarious habit has been observed by those wishing to capture the animals, and while they are unsuspicious a net or other obstacle is placed in the water round the rock on which they rest, and large numbers are captured as they endeavor to escape. They are of a fierce nature and bite furiously when provoked. The flesh is said to be superior to that of the green-turtle. Though ordinarily inactive on land, in the spring the female often makes her way up steep banks to a suitable locality for the deposition of her eggs, which are numerous, sixty or more being deposited at a time. The shell of a large specimen of this species measured eighteen inches in length.

Amyda spinifer is of the same habitat as *A. mutica*, from which animal it can be at once distinguished, however, in that it has the upper portions of the shell provided with several conical prominences. It has been confounded with the Southern *A. ferox* by many writers, though it differs considerably from that animal, in several important particulars. Allied forms are found in the western hemisphere, of which *Chitra indica* is the largest living representative of the family. Specimens have been known to weigh two hundred and forty pounds. It inhabits the river Ganges as well as several estuaries of the Malayan peninsula, and is eagerly sought by the Chinese for food.

Fragments of extinct members of this genus have been found in the cretaceous deposits of New Jersey, and in the tertiary formations of the west; though anything like complete shells are uncommon. These fragments belong to animals resembling those of to-day, and prove the genus to be of great age; a fact that could also have been arrived at by an examination of the animal's structure, which is of a most embryonic type, lacking those points of specialization characteristic of the higher members of the group.

The Emydidæ includes all the so-called fresh-water turtles of the globe, and is by far the largest family of the order; it being represented by at least sixty species, presenting a wide range of structure, habit, and size. The members are characterized by having the shell more or less depressed, though it may sometimes be convex; the toes distinct and webbed, the feet forward for walking or swimming, the claws usually five in front and four behind, though there may be only four toes on each appendage. The shell is invariably covered with horny shields, and those overlapping the tail are not united along their median edges. From only a casual examination of the variety of points presented by this family, it is apparent that it includes animals of diverse habits; there being forms which are not only aquatic, but those which are nearly as exclusively terrestrial as are some of the land-turtles. Of broad distribution throughout the temperate and tropical regions, in North America alone are six genera. The eggs are oblong, deposited in the sand, as are those of the previous family, and the young are circular in outline.

Pseudemys rugosa, the potter or red-bellied terrapin, is an animal of very limited geographical distribution, being found only east of the Appalachian Mountains, and from New Jersey to Virginia. It is, however, quite abundantly found within these limits, and is often captured for market in the Delaware and Susquehanna rivers, though its flesh is not held in great esteem. The length of the shell seldom exceeds eleven inches. The color above is dark slate, with reddish blotches, while below it is of an intense red, ornamented with yellow. The jaws are prominently toothed. *P. concinna* and *mobiliensis* are allied forms, inhabiting the more rocky rivers of the south, but are of limited distribution.

P. hieroglyphica, has been so named from the hieroglyphic-like markings along the margin of the carapax. It sometimes reaches a foot in length, and inhabits the middle, western and gulf states. The yellow-bellied terrapin, *P. scabra*, is of about the same size, though a much less elegant animal, the shell being carinate and deeply serrated posteriorly. It inhabits the warm shallow brooks of fresh water of the southern states, south of the habitat of *P. rugosa*. Specimens are often seen in groups of a dozen or more, collected on some half-submerged log, and, though apparently half asleep in the sun's rays, on the slightest appearance of danger they drop off into the water, the only evidences of their presence being in the carefully protruded snouts these appearing at different points over the surface of the water. Though wary and suspicious, they are, nevertheless, captured in large numbers and sent to market, where they masquerade under the name of 'terrapin.' When in their native element, their diet is chiefly carnivorous, though in confinement they soon accustom themselves to vegetables, of which they seem to become very fond. *P. troostii* is a very abundant form, inhabiting the valley of the Mississippi as far east as Illinois. It was dedicated to Professor Troost, a gentleman who gave no little assistance to Holbrook in the preparation of his work on the American reptiles.

The most interesting species of *Malacoclemmys* is the salt-water terrapin, *M. palustris*, inhabiting the marshes along the Atlantic coast, from Massachusetts to Texas, and even to South America. About Charleston they are very abundant and are captured in large numbers for market, especially is this the case at the breeding season, when the females are full of eggs. Further north they are dug from the salt mud early in their hibernation, and are greatly esteemed, being fat and savory. In the water the terrapin is an active animal, comparatively seldom captured, being always on the lookout and extremely wary. On land it is a good traveler and quite able to escape from any ordinary enemy. In the market it can be distinguished from the other turtles by its short body and the concentric markings of the dorsal plates. The color above is dark brown and pale grayish green. *M. geographicus*, the geographical terrapin, is peculiarly marked and streaked above with narrow reddish lines. It is found in the eastern Mississippi Valley, reaching eastward as far as Pennsylvania and New York.

Chrysemys is characterized by having a deep notch at the anterior portion of the upper jaw, on each side of which the projecting horny sheath forms two teeth. *C. picta*, or the painted-turtle, is perhaps the best known of the American Testudinata. Its geographical distribution is extended, the animal being found from the Gulf of Mexico to the Gulf of St. Lawrence, and inhabiting nearly every pond, pool, or slow stream. While one is riding in the cars, this species as well as *Chelopus guttatus* are seen by myriads, the two clans seldom mixing, crowded together on some projecting rock or half submerged log, their necks stretched out to the utmost, and to all ap-

pearances enjoying the sun to its full benefit. They are, comparatively speaking, active climbers, and may not infrequently be seen perched in situations which would seem to be unattainable by creatures presenting so few adaptations other than natatory. They are timid, however, and quickly retire to the water on being disturbed. Their voracity often leads to an untimely death at the hands of the indignant angler, whom they bother to no little extent by seizing his finely prepared tackle. The ordinary food consists of the succulent stems of various water plants, as well as such unfortunate tadpoles, earth-worms, or larval insects as may fall in its way. Though it begins hibernation early in the fall, but a few warm days in spring are necessary to awake it from its lethargy, when its shrill piping note is heard, often at night making the lowlands ring. The eggs are deposited at evening in a shallow hollow scraped out of the soft sand of some neighboring bank, and carefully covered, where, unless found by some marauding skunk, they are hatched by the sun's heat. This is our most beautiful turtle, its bright colors distinguishing it from all other members of the order. The general color above is dark brown, a yellow line dividing the vertebral plates, which are further

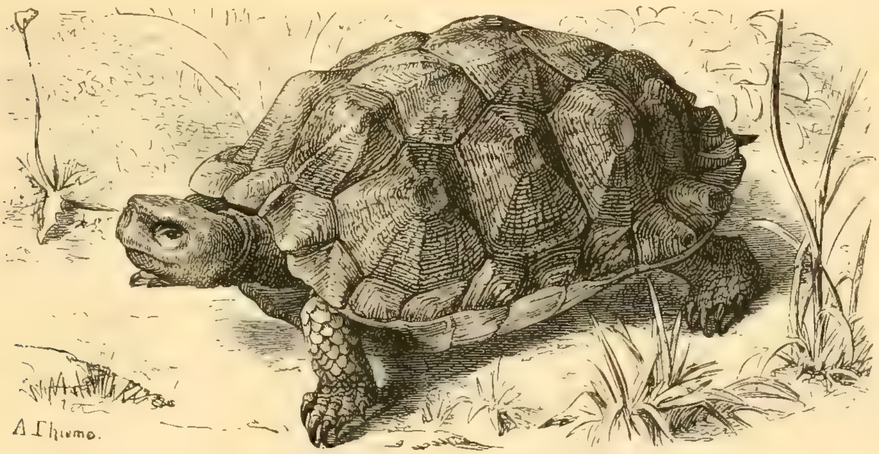


FIG. 258. — *Chelopus insculptus*, wood-tortoise.

bordered, as well as the costals, by broader bands of the same shade. The marginal plates are concentrically marked with deep red, a color which fades away soon after the animal dies. Below, the sternum usually presents an unspotted, uniform bright yellow color, though occasionally a beautiful purple obtains. In the western and more central regions the Oregon turtle, *C. oregonensis*, takes the place of the present species.

Chelopus guttatus, the speckled-turtle, is a familiar form north and east of the Ohio. The small yellow dots covering the black back are very characteristic, and it is a strange fact that they increase in number with age, the young having but a single one on each scale. Its habits are much like those of the painted-turtle. *C. mulenbergii* is limited in its distribution to the valley of the Delaware, and is uncommon. *C. insculptus* has a general distribution coinciding with that of *C. guttatus*, though it is much more local. This animal has received the popular names of horse, sculptured, river, and wood-tortoise, the first possibly being given because of the bright bay color of the animal's body and limb. In certain localities it is an abundant animal, and, unlike other members of the family, is not confined to the water, where it is greatly annoyed by a leech, dozens of which are often found attached to it, but is often met

with some distance from water and often in the dry uplands, where it crawls leisurely along, stopping now and then to feed on the leaves of some favorite plant. On being surprised it quickly withdraws itself into its shell, and might be passed unnoticed were it not that it hisses so loudly. On examination the shell is seen to be composed of very distinct, concentrically sculptured and brown-rayed plates; a prominent ridge being formed along the back by successive longitudinal prominences. Below, the yellow plastron is divided into twelve portions, each bearing on its posterior and outer corner a large black blotch, around which is a series of suture-like grooves parallel with the general contour of the plate. *C. marmoratus* inhabits the Pacific regions.

Emys is represented in North America by a single species inhabiting the more

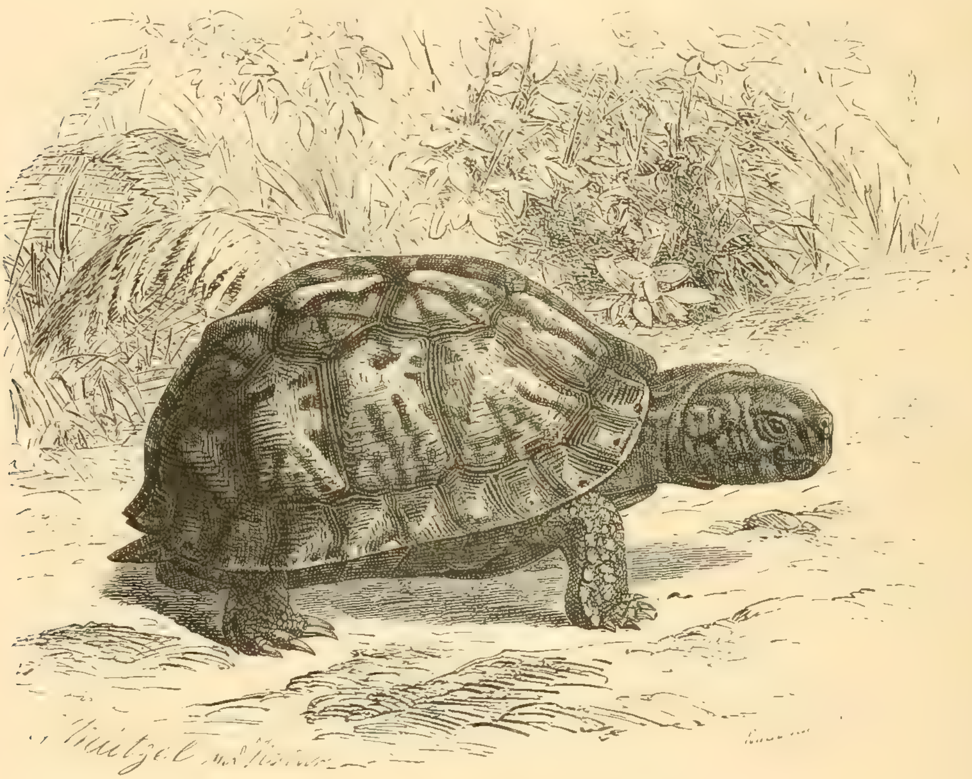


FIG. 259. — *Cistudo carolina*, box-tortoise.

eastern districts from Wisconsin, and known as *E. meleagris* or Blanding's box-tortoise, an interesting form, as it connects the more ordinary members of the family — those having the plastron immovably united to the carapax — with *Cistudo*, where it is not only free, but movable at both ends in a vertical plane. The carapax of this animal is strongly convex and rounded, much resembling that of the box-tortoise, though it is above of a dark green color spotted with yellow. Below, the plastron is provided with a longitudinal ligamentous fulera connecting it with the carapax, and a single transverse hinge, between the six anterior and six posterior plates, which allows, aided by the fulera, after the extremities have been drawn beneath the carapax, of all being protected by the closing of the thus formed lids. Blanding's tortoise exceeds the com-

mon box-tortoise in size. Its young are jet black, and, though the parents are elongate, nearly circular in outline. *E. lutaria* is the European representative.

The genus *Cistudo* includes the common box-tortoise, inhabiting the United States east of the Mississippi, and presenting more variety of form and coloration than any other member of the family. It is in most localities quite abundant, and is found in pastures and uplands, seeking its food of 'toad-stools' and 'mushrooms,' and may at once be recognized, in that it is able, by means of the two lids of the plastron, to completely enclose itself in its shell, and in having its upper jaw unprovided with the anterior notch so characteristic of the previous form. Though the shell seldom

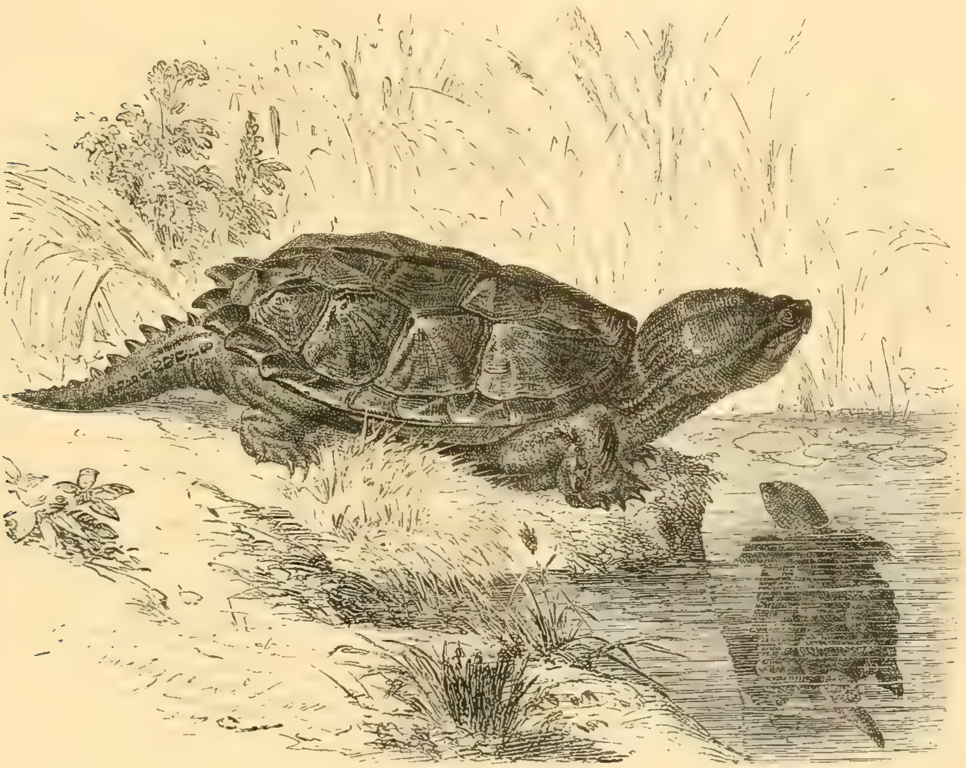


FIG. 260. — *Chelydra serpentina*, snapping-turtle

measures over seven inches in length, the animals live to a most remarkable age, seemingly until put to some violent death. A venerable box-turtle was recently seen which bore dates of the latter part of the last century, as well as successive dates of the present. There have since been five generations in the family of the one who first carved his name on the plastron of this respected resident. Unlike our other turtles, this species, *C. carolina*, has a particular dislike for the water, and soon dies if placed in it. The toes often vary in number with different individuals, those having only three on the hind feet being not uncommon in the more western and southern habitat. *C. ornata*, a form which always has the vertebral scales keeled, and is depressed and rounded, inhabits the valley of the upper Mississippi and the country lying south.

The genus is well represented in Europe by the yellow-tortoise, *C. europæa*, inhabiting all the warmer countries, where they are to a limited extent used for food.

The family CHELYDRIDÆ is represented in the New World, from Canada to Ecuador, by the common snapping-turtle, *Chelydra serpentina*, an animal adapted for active defence. The shield being too small for the complete retraction of the extremities, the enemy is boldly faced and attacked, the reptile's long reach and strong jaws being sufficient to defeat the attacks of any ordinary foe. The elongated tail of this animal is very characteristic, and from its appearance has not only given rise to the popular name, 'alligator-turtle,' but, appended to the small, comparatively thin shell, gives an elongated appearance to the body, resulting in the specific name, *serpentina*, In its habits, both in the water and on land, the snapping-turtle is bold and fierce, and will often suffer itself to be lifted from the ground by the object which it has grasped rather than let go its hold. As it elevates itself for the attack, with half-open mouth and sullen eyes, there is something fierce and defiant in its attitude, though it is so slow and awkward in recovering itself after missing its point of attack that it presents a most ludicrous picture. Members of the species are remarkably strong — the elder Agassiz states that he has observed one to bite off a piece of plank more than an inch thick — and they grow to a considerable size, being our largest inland representative of the order, specimens not infrequently exceeding the length of three feet. In the northern states, from the tenth to the twentieth of June, the female, at early morning, leaves the water and crawls to a sand bank, digs a small cavity, not with its tail (a popular belief), but with its hind leg, into which the small spherical eggs are deposited to the number of twenty-five or thirty, when the sand is drawn over them, the surface smoothed down, and the animal is soon back in the water, the entire operation not lasting over twenty minutes. This mode of oviposition is different from that of our other turtles. While the snapper is satisfied with nothing but sand, the painted and speckled-tortoises put up with any soil in which they can scrape, not a cavity, but a hollow, and at evening rather than early morning. An allied form, *Macrochelys lacertina*, inhabits the tributaries of the Mexican Gulf, extending northward in the Mississippi as far as Missouri. Its diet, like that of the previous species, consists of the smaller animals, which it captures by a quick lunge, seizing them in its powerful jaws.

The family CINOSTERNIDÆ includes the smaller fresh-water turtles, the largest of which is smaller than the smallest of the Chelydridæ. On leaving the water they seldom attempt any long journey, but bask in the sun in such a situation that on the slightest sign of danger they can drop into their native element, though, if so unfortunate as to be captured, they, though ridiculously small, endeavor to defend themselves by freely using their jaws. They are carnivorous, and possibly, to some extent, herbivorous. The eggs are few in number, and, unlike other turtles, excepting the Trionychidæ, are covered with a strong glazed shell, which, though thick, is very brittle.

Aromochelys odorata is a small turtle found in pools, often covered with a thick growth of green algæ, inhabiting the more eastern portions of the United States, and known as the musk-turtle, besides other savory names, of which the scientific is perhaps the most expressive. In length the shell of this animal seldom reaches six inches, while the plastron is cruciform, resembling to some extent that of *Chelydra serpentina.* The convex brown carapax, generally covered with algæ, the pointed head and strong odor, renders this animal not easily confounded with our other turtles.

Testudo elephantopus, Galapagos tortoise.

Cinosternum has four representatives in the United States, of which *C. pennsylvanicum*, the mud-tortoise, very generally distributed over the southeastern two thirds of the United States, is of small size and resembles the previous species, though the plastron is divided in to transverse portions, the anterior and posterior of which are capable of more or less vertical motion, enabling the retracted head and limbs to be more thoroughly protected. It is an animal which readily takes the bait, and is of no little annoyance to the angler. Other species are found in the southwestern parts of the Union.

TESTUDINIDÆ embraces those turtles which have the shell very convex and whose feet are developed for a terrestrial life. The toes are distinct, the feet club-shaped, and the caudal plates united. The North American representatives are two in number,

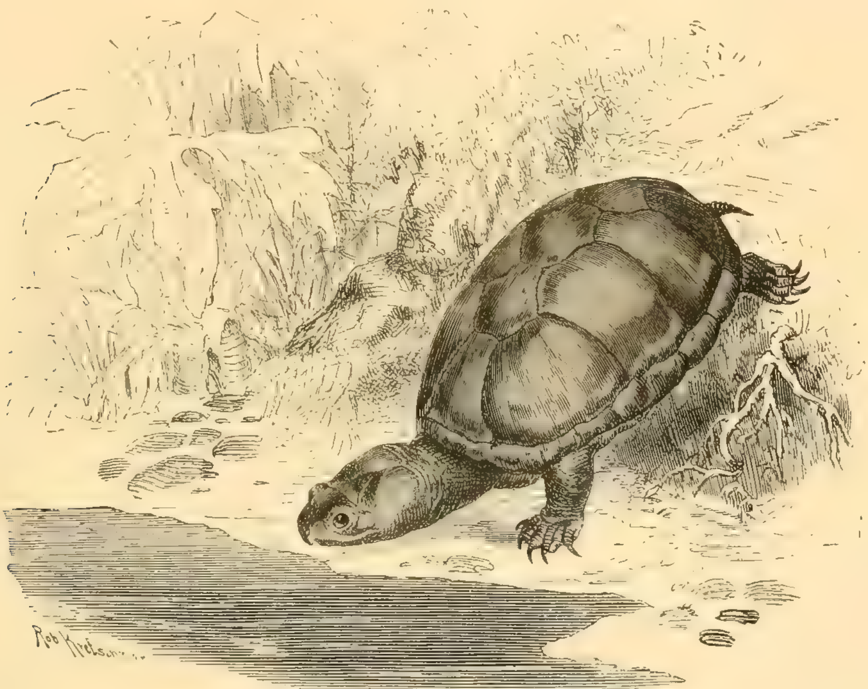


FIG. 261. — *Cinosternum pennsylvanicum*, mud-turtle.

Testudo carolina and *T. agassizii*, the latter of the southern Pacific and the region around Sonora. The former, the common 'gopher,' the shell of which is often fifteen inches in length, is a strong animal, and is more or less gregarious, troops being often met with in the pine-barren country. Though in confinement they eat at all times of the day, they are said to be, naturally, of nocturnal habits, making midnight raids on the farmers' sweet potatoes, bulbous plants, and melons, and retiring to their burrows during the warmer portions of the day, or on the approach of showers, where they also hibernate. These homes are inhabited by a single pair, and are dug to a length of four feet, the interior being large and spacious, while the mouth is only the size of the larger animal. The negroes, in capturing the 'gophers,' sink a deep pit in front of the hole, and the unfortunate animals, on sauntering out, as they are obliged to daily, drop in, and are unable to escape. The females are considerably larger than

the males, and are very strong, the weight of two hundred pounds having been said to be carried on the back of one. The eggs, which are about the size of a pigeon's, and five in number, are much esteemed for food. They are deposited in a hollow near the mouth of the burrow. The South American *T. tabulata*, has been confounded with this animal, though it is now proved to be a distinct species.

The only European representative of the genus is the common land-tortoise, *T. græca*, commonly made a pet of in gardens, though its true home is along the southern countries bordering on the Mediterranean, where it is captured for its flesh, and often put on sale in the markets. They are animal as well as vegetable feeders, and are extremely fond of the leaves of lettuce, often using their feet to assist them in divid-

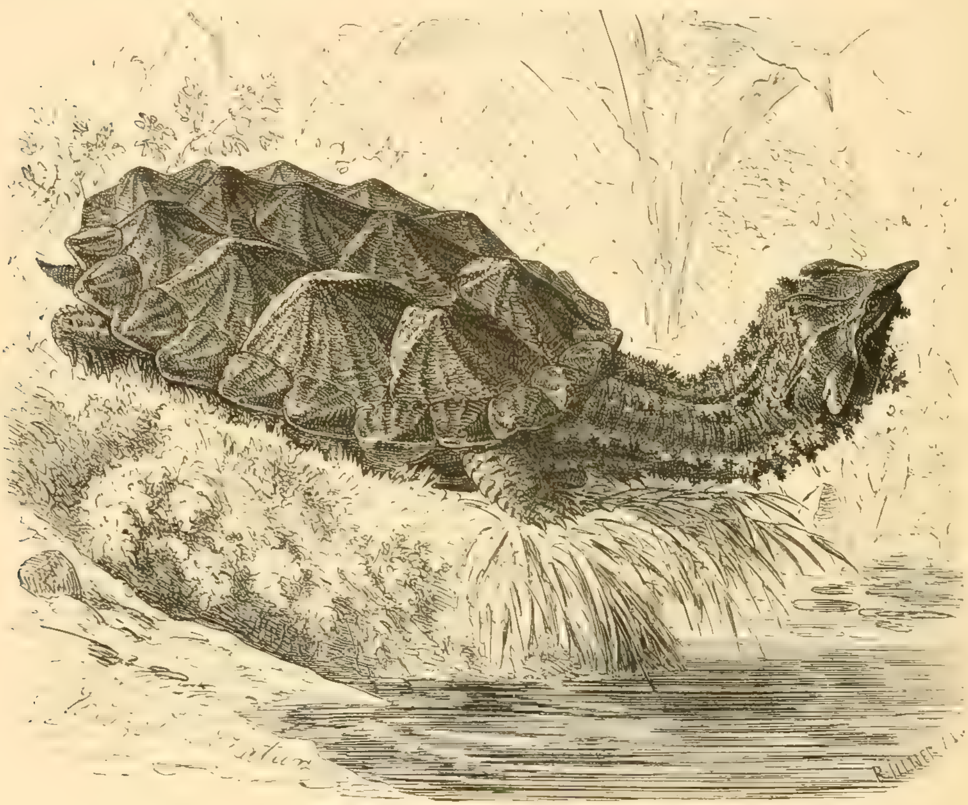


FIG. 262. — *Chelys matamata*, bearded-turtle.

ing the larger leaves. In confinement they drink milk, and eat almost anything that may be given them of a vegetable nature. A strong liking for artificial heat has been evinced.

The land-turtle of the French markets is captured along the coast of Morocco, and in the neighborhood of Algiers, from which places they are shipped. It considerably exceeds the Greek-turtle in size.

The largest representative of the family is the so-called Indian-tortoise, an animal inhabiting the Galapagos Islands, and, though originally described as *T. elephantopus*, the individuals from the several islands are now known to present variations of specific value. Closely allied forms are found in Madagascar.

In a few cretaceous turtles found in the New Jersey green-sand, as well as in several deposits of the same age in the West, and allied to the Testudinidæ, there are presented peculiarities of structure which are so exceptional that they have been united in a family by themselves. They are of peculiar interest to the paleontologist, being generalized forms of position intermediate between the Emydidæ and Hydraspididæ.

To the gigantic river-tortoise, *Podocnemys expansa*, of the Amazon has been given a family value. It is of an enormous size, and is a load for the strongest native, the shell, when full grown, measuring nearly three feet in length. In the upper portions of the Amazon every household has a pond or corral, in which the animals are confined

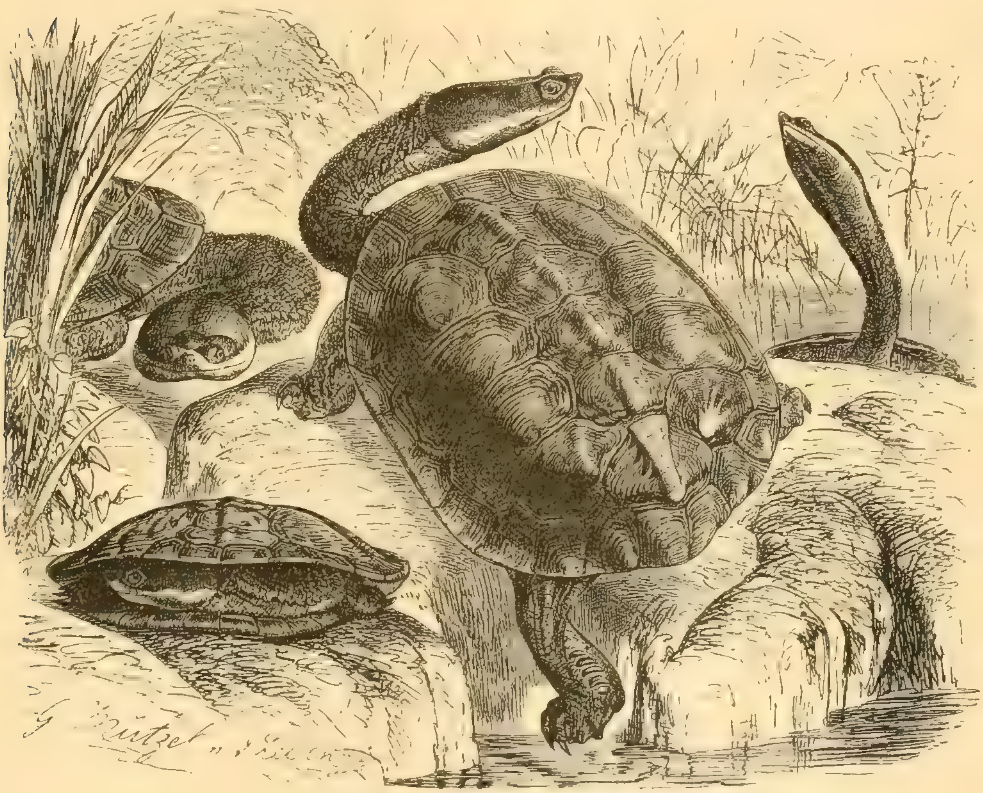


Fig. 263. *Hydraspis maximiliana.*

during the time of dearth, the wet months. Though the rich people hire servants to capture the animals when the water is low, the poorer classes are obliged to collect them themselves, as markets are unknown. Their abundance varies with the height of the river, in dry seasons the largest numbers being captured. The flesh is very tender, palatable, and wholesome, though one soon tires of it as a regular diet. The eggs are eagerly sought after by the natives, and, that all may have equal advantages, the excursions to the sandy islands are made in a body, all setting to work at a given signal.

In the family Chelydidæ the elongated neck cannot be withdrawn into the body, as in the ordinary forms, but protection is obtained by bending it round against the

sides of the body and hiding it, as it were, under the eaves of the shell. *Chelys matamata*, the remarkable fimbriated or bearded-turtle, belongs to this family. This is one of the most peculiar creations of nature, in oddity being exceeded by none. It inhabits the warm fresh-water pools of the tropical portions of South America, and has been, until of late years, quite abundantly found, though, from the unceasing draft made upon it for food, it is now quite uncommon. It is said to be a carnivorous animal, lying in wait, concealed by the rushes of some quiet body of water, for an unsuspecting fish or reptile, or possibly a brood of young ducks, which it captures by a quick extension of its neck. It grows to a considerable size, sometimes reaching the length of three feet. As is shown in the engraving, the snout is greatly prolonged, and the sides of the head and ridges of the neck are provided with peculiar prolongations of the skin, the true office of which is not known. An allied form, *Hydraspis maximilianii*, also inhabiting Brazil, has been given a family value by some naturalists. The figure illustrating this animal shows the peculiar manner in which the head and elongated neck is protected by being applied to the side of the body rather than being withdrawn into the carapax.

The family Pelomedusidæ includes the single genus *Pelomedusa*, which is characterized by having but two series of phalanges instead of the usual number, three. *P. subrufa* and other species inhabit South Africa.

The highest family of the order, Sternothleridæ, is based on the peculiar structure of the anterior divisions of the plastron, which are separated transversely, giving the animals ten plates instead of the usual number, eight. This peculiarity is similar to that presented by the genus *Pleurodira*.

Order V.—RHYNCOCEPHALIA.

The fifth order of reptiles includes a small number of animals resembling in general outline some of the lizards, though presenting several internal characteristics, as the possession of bi-concave vertebræ and immovable quadrate bones, which are at variance with the forms already treated and are of ordinal value. But a single representative, the *Hatteria* or *Sphenodon* of New Zealand, is still living, though the paleontologist has brought to light the bones of a few pre-existing forms.

The Hatteria is one of those isolated animals which, from the peculiarity of its structure, is of interest to the anatomist; as throwing light on the more obscure points in the structure of fossil relatives, and, to the systematic zoologist, fills, as a single specimen, the place of species, genus, family, and order. The general appearance is iguana-like. The tail is compressed and crested, and, like many lizards, being of a brittle nature, is often found reproduced, but without vertebral segmentation. The general color is, above, dull olive-green spotted with yellow, and below, whitish. Besides the peculiar fish-like vertebræ and rigid quadrate bones, some of the ribs are provided medially with uncinate processes, resembling those of crocodiles, if not more strongly those of birds. Third and intermediate portions, like those found in the monotremes and sloths, unite the dorsal with the sternal costæ. Teeth occur not only on the jaws, but also on the palatine bones, where they are arranged in a regular series, parallel with those of the maxillaries. The total length seldom exceeds twenty inches. At one time these animals were to be found in abundance along the rocky shores and small islands of the New Zealand coast, where they lived in the crevices of the rocks, or in small burrows of their own construction. Of late, however, being

used as an article of food by the natives, and suffering from the introduction of hogs, they have become uncommon, and will soon be numbered with the animals which once existed but are now extinct.

Of the fossil members of this order, the *Proterosaurus* is of particular interest, as it was the first known fossil reptile, being described as early as 1710 from fragments obtained in the permian beds of Thuringia. A study of the bones of the head, neck, and limbs shows it to have been an aquatic animal of considerable size, capable of seizing and retaining the active fishes which sported in the waters that deposited the old Thuringian copper-slates. *Rhynchosaurus*, from the trias of England, is of interest in that the jaws, like those of turtles, are unprovided with teeth, and the premaxillaries present a curved beak, strongly resembling that of birds. The vertebral centra are, however, like those of *Hatteria*, biconcave. *Hyperodapedon*, also triassic, is an allied form.

Order VI.—ICHTHYOPTERYGIA.

The members of this order are all extinct, and are only known from their fossil remains, which have been found in the tertiary deposits of the Old World. Though true reptiles in structure, the *Ichthyosauri* resembled in general outline, and probably also in habits, the cetaceous mammals of to-day. The broad head, short neck, thick body and short vertebræ resemble these portions of the whales, a general resemblance carried still further by the flipper-like limbs and elongate, probably fin-bearing, tail which performed the office of a propeller. Some of these saurians were colossal in size, reaching a length of forty feet, though many were smaller and resembled the dolphins, being about six feet or even less in length. That the animals were reptiles is at once seen, however, on an examination of the brain cavity, which is of most diminutive size when compared with that of sea-mammals, and is not protected by a solid cranium, the bones of the head being more or less imperfectly united together. The vertebral centra, moreover, were biconcave, and the orbits, which were enormous, sometimes fifteen inches in diameter, were protected by a circular series of triangular plates which may have assisted in adjusting the focus of the eyes, or may have been in their nature merely protective. A study of the jaws, as well as of the half-digested contents of the alimentary tract, proves the *Ichthyosaurus* to have been a predatory animal, inhabiting the open sea as well as the shores, and feeding on fish and other marine animals. Though awkward in its movements, it not infrequently quitted the water and crawled out on some exposed sand-bar to rest or to bask in the sun. *I. communis* is the most common form.

The *Sauranodon*, found in the Jurassic deposits of the west, resembled the *Ichthyosaurus* very closely, though it differed in being destitute of teeth. It is given by some an ordinal, while others consider it of only family, value.

Order VII.—THEROMORPHA.

This order includes several extinct reptiles, fragments of which are found chiefly in the Permian and triassic fresh-water deposits of South Africa. The teeth are either wanting or are represented by a pair of maxillary teeth. The vertebræ are biconcave, and the ambulatory limbs are supported by a solid pelvis and firm shoulder-girdle. It was from this order that the mammals are by some supposed to have branched off,

the scapular and pelvic arches, as well as several bones of the limbs, being remarkably like those portions in the Monotrema, especially *Echidna*. From a comparative study of the *Pelicosauria*, the fact has been demonstrated that the first terrestrial Vertebrata possessed a notochord. The *Dicynodons* are known from fragments of their skeletons found fossilled in South Africa, and received their name from the Greek, 'two-tusks.' The skull presents characters which are crocodilian, chelonian, lacertilian, and, in the elongate canine teeth, mammalian. The lower jaw was remarkably turtle-like and was probably encased in horn. Several species have been described. The *Oudenodons* were without teeth or had them inconspicuous. The head was rounded anteriorly, and in general outline strongly resembled that of the turtles. The *Pelicosauria* are represented by two dozen or more species from the permian beds of America; *Clepsydropus*, from Texas and Illinois, is illustrative.

ORDER VIII. — SAUROPTERYGIA.

The European and New Zealand cretaceous beds have yielded by far the greater number of species to this order. Of the few American forms, *Elasmosaurus* is the most interesting. This animal differed from the *Plesiosaurus* in the structure of its pectoral girdle, and was of an elongated form, sometimes forty-five feet in length, and could swim rapidly through the water by using its flattened limbs as oars, or by propelling itself, the tail being long and paddle-shaped. The neck and small head resembled in their motions, as they twisted from side to side or plunged beneath the surface these portions of the swan. It has been found, from an examination of the debris occupying what was once the body cavity of these sea-saurians, that they fed on the more ravenous fish, which they were enabled to grasp and retain by means of their long, sharp teeth.

FIG. 264. – Skull of *Dicynodon*.

While the *Elasmosaurs* ploughed the American waters, the *Plesiosauri* were no less abundant in the eastern hemisphere. The first fossil representative was found in the lias of Lyme Regis, and, from its peculiar lizard-like form, derived its name, 'near to lizard.' The discovery of this genus was considered by Cuvier to be of great importance, as presenting peculiarities of structure the most anomalous. Perhaps the better way to describe the animal is to follow the words of an early naturalist: "To the head of a lizard it united the teeth of a crocodile, a neck of enormous length, resembling the body of a serpent, a trunk and tail having the proportions of an ordinary quadruped, the ribs of a chameleon, and the paddles of a whale." The openings of the nostrils were far back, in front of the eyes, and may have been used as spout-holes. Of a score or more of species which have been described, *P. dolichodeirus*, which attained a length of twelve feet, is, perhaps, the most commonly found. The neck was of great length, exceeding, by several vertebræ, that of the swan. A study of the ribs shows the animal to have been capable of taking in a large supply of air, and the inference is that it could remain submerged for a considerable period of time. It was, moreover, less adapted for a pelagic life than the *Ichthyosaurus* and probably seldom wandered far from the more shallow waters.

Order IX.—CROCODILIA.

This order embraces those aquatic reptiles which have the teeth firmly implanted in the jaws, the body protected by a thick, armored skin, and the four limbs and tail formed for swimming as well as for crawling. While in the previous order the limbs were only represented by paddles, we now come to animals which not only have these appendages freely articulated, but have them ending in separate digits. The skin is thick and heavy, and bears, in its dorsal regions, strong, osseous plates. The jaws proper are the only bones which bear teeth, and these are wedged into alveoli and are conical in outline. The fourth tooth of the mandible often considerably exceeds its fellows in size and fits into an excavation in the upper jaw. It is used as the chief organ of prehension. The structure of the vertebral centra varies in the several suborders, though all the existing crocodiles have them concave anteriorly. The structure of the soft parts is the highest presented by living reptiles. The organs of special sense are well developed. The eyes have the pupil vertical, and are protected by two lids, and also by a nictitating membrane. Both nostrils and ears are provided with cuticular valves. The buccal cavity has posteriorly an arrangement which prevents water from passing into the pharynx, when the mouth is held open by the struggling prey. The stomach is remarkably bird-like and passes into a zigzag intestine, to which are attached no cæcal appendages. The intestine decreases in size before entering the cloaca, which gives attachment to the erectile copulatory organ. The heart is highly developed, and, in having a distinct right and left ventricle, effectually prevents the mixture of the venous with the arterial blood. The order is divided into three groups, of which the procelous, existing crocodiles, and the fossil *Thoracosaurus* will be first treated.

The crocodiles inhabit the warmer portions of America, Asia, Africa, and Australia, and naturally divide themselves into three groups: The gavials, having the cutaneous plates of the top of the head and back continuous, and the canine teeth of the lower jaw fitting into notches in the margin of the upper jaw; the crocodiles proper, having the plates of the head separated from those of the back, but having the canine teeth fit into notches as in the previous group; and the alligators, having the plates of the back like the crocodiles, but having the teeth fit into pits rather than into notches.

The gavial, or nakoo, of India, *Gavialis gangeticus*, has the snout elongated, linear, and swollen at the tip, and the lateral teeth oblique. This animal is one of the largest of the order, and sometimes reaches a length of twenty feet. Old males have the nasal sacs at the tip of the snout considerably enlarged, and are thus enabled to remain below the surface for a considerably longer period than are the females. The development of the snout is of peculiar interest, since the young have it broad and depressed like the alligators. In some of the rivers of India, as a result of a superstition among the ignorant natives, who fear to harm them lest they arouse the anger of the gods, the gavials have become so abundant as to be destructive to human life.

The genus *Tomistoma* has the beak conical, and the teeth erect and received into pits; it is intermediate between *Gavialis* and *Crocodilus*, and is represented by but a single species, *T. schlegelii*, which inhabits the island of Borneo.

Of the crocodiles proper, representatives are found in every continent. *Crocodilus vulgaris*, the Nile crocodile, is found throughout Africa from north to south

and from east to west, and has been known from time immemorial, not only being mentioned in the oldest manuscripts, but appearing on the walls of the ancient Egyptian monuments, which almost antedate history, and is not infrequently found preserved as a mummy. In the upper regions of the Nile these animals actually swarm, and though killed by the hundreds by hunters, and when young by the thousands by their natural enemies, they seem in this locality to hold their own in spite of all persecution. Though rendering the African rivers dangerous to travelers, and destroy-

FIG. 265. — *Gavialis gangeticus*, gavial.

ing many of the herdsman's cattle, by seizing them by the snout as they are about to drink, the crocodile, preferring, as it does, the more putrid flesh, as a scavenger is of considerable value, performing in the water what the hyæna does on land. Livingstone, in writing of this animal, says it often seizes children as they play on the banks of the rivers, not infrequently rendering them senseless by a blow of the tail. The full-grown natives are, however, seldom attacked, except when they at night attempt to swim across the rivers or enter where the animals are particularly abundant. Ant-

elope are often seen to disappear from view as they seek the water to avoid the hounds, and the dogs are especially palatable to the huge reptile. It is said that the animals acquire a taste for human flesh. In localities where they once caused no great fear, on receiving the dead bodies of criminals, they at length became so ferocious as to be greatly dreaded. The natives kill them by thrusting a barbed spear into their side as they lie unsuspectingly on the bank, or they dig a pit in some frequented path, into which the reptile falls as it flees from the cries of the savages as they "beat the bush."

FIG. 266. — *Crocodilus americanus*, crocodile.

An ancient story, supposed for a long time to be fabulous, is told by Herodotus, the verity of which has been established by the later naturalists. The ancient writer said: "When the crocodile takes his food in the Nile, the inside of its mouth is always covered with a small fly. All birds, with a single exception, flee from the crocodile, but this one, the Nile bird, *Trochylus*, far from avoiding it, flies towards the reptile with the greatest eagerness and renders it a very essential service. Every time the crocodile goes on shore, the Nile bird enters the mouth of the terrible animal and

delivers it from the fly which it finds there; the crocodile shows its recognition of the service and never harms the bird." In the modern classification this bird is the *Charadrius ægypticus.* The eggs of the crocodile are laid in sand, and left to be incubated by the sun's rays, though the female remains in the neighborhood and watches the place of deposit with considerable maternal solicitude. *C. nigra* and *C. cataphractus*, the black and the false-crocodile, are confined to the rivers of the west African coast.

The Indian *C. porosus* is found only in the salt-water estuaries, and has been captured not only around the peninsula of India, but among the islands of the East Indies, as far south as the coast of Australia. From a peculiar ridge over each eye, this form is popularly known as the double-crested crocodile. The young show their fierce natures from the first, and will often allow themselves to be lifted from the water, by retaining their hold on a stick that may have been thrust at them in way of annoyance. During the warmer portions of the year, the double-crested crocodile not infrequently avoids the heat of the sun by hiding in the mud, and remaining thus concealed until the approach of the wet season. The American crocodile, *C. americanus*, was first supposed to be confined to the West Indies and South America, but it is now known to be not infrequently captured in different parts of Central America and occasionally on the peninsula of Florida. It can be at once distinguished from the alligator by its narrow snout, as well as by other characters of the genus already given. Specimens twelve feet in length have been captured. The Orinoco crocodile, *C. intermedia*, has a few times been known to wander north, and may possibly have been met with in Florida. It differs from *C. americanus* in having the snout more slender and the plates of the back more nearly uniform.

Perhaps no reptile is better known to the American than the alligator. Abounding in the low, stagnant pools of the south, its dull body a characteristic feature of the unfrequented morass, and common not only in the cheaper menageries of the north, but as a pet of the amateur zoologist, it is recognized by all and needs no specific description. Though but a few years since seen by the hundreds during a day's journey along the low, muddy shores of the southern and gulf states, it has of late, from the incessant massacre to which it has been subjected by travelers and sportsmen, become less common, and will undoubtedly retire before the advance of the southern settlers. Of its habits, when undisturbed in its native wilds, relatively few have been the observers. It spends the most of the day lying on some low bank or log, where it can receive the genial rays of the sun, though it retires to the water on being disturbed. When thus basking, they are sometimes captured by the more daring hunters, and, with limbs bound, are hurried off to the northern showmen.

The animals may resent being captured so easily, however, and may give the collector no little trouble. That they often voluntarily attack people is doubtful, though there are several instances of their pursuing boats and regarding the inmates with the most suspicious glances. In the water they are very active, and, being strong swimmers, are able to catch the larger fish with but little trouble. For animals, like the musk-rat, swimming across lagoons, they are always on the watch, and many is the disappointed sportsman who has returned home after seeing his hound seized by one of these monsters. Of dog-meat they seem to be particularly fond, and it is said they will congregate on hearing a puppy whine. On seizing its prey the alligator sinks with it to the bottom, and there remains until all struggling has ceased, it is then able with less trouble to tear it in pieces. While thus submerged, the peculiar collar at the

base of the tongue prevents the water from passing into the lungs, and the reptile may even come to the surface and breathe without letting go its hold on its prey. That the reptile uses its tail to sweep animals off the bank into its jaws savors rather of the fancy, though this appendage is often used in self-defence, and is an efficient organ. Not infrequently the alligator can be induced to take the hook, and, when thus captured, will test the strength of the strongest 'shark-tackle.' It is, however, when captured, of a most disagreeable nature; not only does it use its jaws freely, but

FIG. 267. — *Alligator mississippiensis*, alligator.

it emits a most disagreeable odor of musk, which is almost unendurable; it has, however, been used by some as food, Catesby saying: "The Hind-part of the Belly & Tail are eat by the Indians. The Flesh is delicately white, but has so perfumed a Taste of Smell, that I could never relish it with Pleasure." It is also maintained that the negroes, during the colder months, often dig it from the mud in which it is hibernating, and use its flesh. In the stomach are often found the most unexpected articles: stones, bottles, boots, and in one case a camp-stove performed its share of the grinding operation.

In the breeding season, the spring and early summer, the reptiles are very noisy and bellow with thunder-like power. The eggs are deposited in some natural sandy hillock, or in a mound of the reptile's own construction, the young, on hatching, at once directing their course to the water. The eggs are often taken from the nests, however, by tourists, and illegally mailed to northern friends, when they hatch in a climate unsuited to their wants and usually die, though a few have been known to take food and prosper. Adults seldom reach the length of twelve feet. The name given by science is *Alligator mississippiensis*, the animal being found in that river as far north, though rarely, as the Ohio.

The Orinoco cayman, *Jacare nigra*, was the animal with which Waterton had the struggle so geographically described in his "Wanderings." It seems that the naturalist desired a specimen for dissection, and hence one mutilated as little as possible. One of the reptiles was first caught by a cleverly devised hook, and, when drawn on the bank, was mounted by Waterton, as he would mount an English hunter, the reptile's fore feet and legs serving as reins. It is needless to say that it was only by the exercise of considerable skill that the naturalist kept his seat, though he finally succeeded in exhausting the furious reptile. An old hunter and fisherman in southern Louisiana assured me that in a similar manner he had captured alligators for showmen.

Closely allied to the now existing crocodiles was the genus *Thoracosaurus*, inhabiting, in cretaceous times, the shores of New Jersey, as well as the coast of France, and resembling to no little extent the Indian gavial. *T. neocœsariensis*, once inhabiting the more eastern portions of our continent, was one of the largest species. The *Teleosaurus*, from earlier deposits, had the jaws greatly elongated, considerably exceeding, in proportional length, those of the gavial of to-day, and armed with long sharp teeth, which enabled them to capture and retain fishes, the only large vertebrates inhabiting the Jurassic seas suitable for food. *Goniopholis crassidens* resembled the *Teleosauri* in having biconcave vertebræ, though its teeth resembled those of the existing crocodiles.

The Belodontidæ, though at first considered otherwise, now hold an important position in the present order. *Belodon lepturus*, the largest of the genus, reached a length of ten feet, and was strong and stout. It lived on the American shores during the triassic period, and was, judging from the posterior position of its nostrils, and probably webbed feet, an aquatic feeder, searching with its elongated snout below the surface for such unfortunate animals as might come within its reach, while respiration was still maintained, as a result of the nostrils being placed almost as far back as the eyes. This genus includes the earliest known representatives of the order. Remains are found in the European as well as in American deposits.

Order X.—DINOSAURIA.

In this extinct order appears a series of reptiles, some of most gigantic size, though many are small, which are of particular interest to the systematic zoologist, as many forms, on examination, are seen to possess peculiarities of structure which point towards the lower birds, while others have many points of structure in common with the mammals. The avian peculiarities are not merely superficial, the pelvis and hind limb is remarkably bird-like, and is often of a development which justifies naturalists in considering the reptiles to have been biped, a supposition confirmed by the three-toed tracks of the Connecticut valley. We have consequently in the Reptilia a

Jacare nigra, black caiman.

series of forms, from those which walked about on all fours to those which stood erect, an instance of evolution paralleled in Mammalia.

The first representatives to receive treatment will be those which had the proximal tarsal bones separate from each other and movably articulated to the terminal faces of the tibia and fibula. *Hadrosaurus* had the teeth in several rows, and so juxtaposed as to give a pavement-like appearance to the armature of the jaw. The members of this genus were of gigantic size, being twenty-eight feet in length, the thigh-bone alone having been forty inches long, though the humerus was only about one half this length. The animals wandered through the old American forests and used their small fore limbs to grasp the branches of trees and direct them to the mouth. In water as well as on land they were active.

Closely allied to the previous reptiles, though having the teeth in a single row, was the *Iguanodon* of the European Jurassic, an animal presenting many points of structure in common with the iguana of to-day. Especially iguana-like were the peculiar teeth. Though in the several museums of Europe there are many fossil representatives of this genus, the skeleton of *I. bernissartensis*, lately found in Belgium, and now in the possession of the Brussels museum, is by far the most perfect, there being but a few fragments missing. The animal walked on its hind limbs, as do the birds, and left in the Wealden strata its three-toed tracks. The fore limbs, as will be seen from the figure, were extremely short, and, besides being used in gathering food, were probably organs of defence, the thumb being covered with a strong, conical spine, which could have pierced through the body-walls of any animal which might unwittingly lead an attack. When standing up, as it did while feeding, the *Iguanodon* had a stature of fourteen feet, though when stretched out in the water, its broad tail acting as a propeller, it probably was twenty-eight feet in length. *Scelidosaurus* differed from the *Iguanodon* in having four digits on its hind feet, though its teeth were in a single row. Specimens are very uncommon.

Fig. 268. — *Iguanodon bernissartensis*, as restored by Dollo.

In 1878 what was then the largest known land animal was described by Professor Cope as the *Camarasaurus supremus*, a reptile having the fore and hind limbs well developed, the femur alone being six feet in height, and the animal having a total length — including the strong and elongated tail — of about eighty feet. One of the dorsal vertebræ measured over three feet in width, and equalled in size those of the right whale. Such a huge reptile wandered about on the shores, or in the shallow water, where it could easily reach to the tops of the larger shrubs, or, by resting on its haunches, it might browse on the tops of trees. It held its own, as a fossil, without a rival, for only a short time, for soon, from the same deposit, the early cretaceous of Dakota, appeared the bones of an allied animal, but differing in having the vertebral centra strongly biconcave, or amphicœlous, a peculiarity which gave origin to the

generic portion of the scientific name, *Amphicœlias alatus.* The femur of this animal, though exceeding in length that of the *Camarasaurus*, was much more slender and probably supported a less bulky animal, though one that probably had a greater height. It is estimated that *A. alatus* could reach to the tops of trees thirty feet high. But huge saurians did not stop with the discovery of this species, for soon there was brought to light the fragments of an animal, one of whose dorsal vertebræ measured six feet from the base of centrum to tip of spine, and, if of similar proportions to its congener, its femur must have measured twelve feet, and the whole animal may have exceeded the length of one hundred feet. This species has been named *A. fragillimus*, and possibly walked along the rocky shores, submerged in the water, and feeding on algæ or other vegetable matter.

The figure illustrating the skeleton of *Brontosaurus* was made from a single individual of about fifty feet in length, and beautifully illustrates the peculiarities of structure presented by members of this group. The head, it will be seen, does not exceed in size some of the bones of the neck, and the brain cavity is of the smallest dimensions, indicating an animal of stupid habits. Such a reptile may have splashed round in the water in search of marine vegetable growths, each time it placed one of

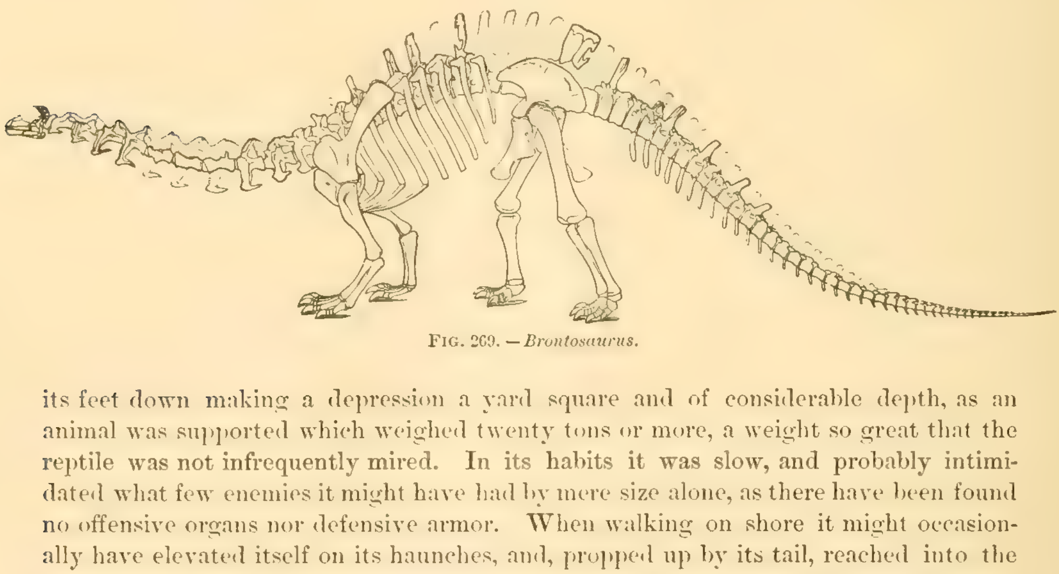


FIG. 269. —*Brontosaurus.*

its feet down making a depression a yard square and of considerable depth, as an animal was supported which weighed twenty tons or more, a weight so great that the reptile was not infrequently mired. In its habits it was slow, and probably intimidated what few enemies it might have had by mere size alone, as there have been found no offensive organs nor defensive armor. When walking on shore it might occasionally have elevated itself on its haunches, and, propped up by its tail, reached into the tops of the trees and browsed on the leaves and small branches. In this upright position, however, it is not likely that the animal could progress for any great distance.

We now come to the group of Dinosaurian reptiles which had the tarsal bones united with the tibia and at an angle, effectually preventing the foot from being extended in a line with the leg, a peculiarity of structure presented also by the young chick. The most interesting genus is *Lalaps*, some of the representatives of which stood eighteen feet in height and were carnivorous animals of the most rapacious habits. They undoubtedly kept within proper limits animals which might otherwise have unduly increased in numbers. The structure of the bones of the hind limb show *Lalaps* to have been a plantigrade biped, while the massive tail gives reason for believing that, when at rest, a position was taken not unlike that maintained by the kangaroo. The jaws were of considerable size and armed with sharp lance-like teeth,

which could probably tear through the tough hide of even the *Hadrosaurus*. While hunting, the Lælaps probably wandered around the lowlands, or swam along the shore, until it arrived within twenty-five or thirty feet of its victim, when, with a spring, it cleared the distance, crushing its prey by the weight of its fall, and tearing it to pieces by means of its stout claws and sharp teeth. The crocodiles must have regarded this animal as their greatest enemy, excepting the sharks, while the smaller Dinosaurs probably held it in the same esteem as do to-day the jackals the lion, an animal which leaves much that to them is useful.

ORDER XI. — ORNITHOSAURIA.

We have now reached the highest order of reptiles, the members of which, all now extinct, resembled the birds most, of living animals. The fore and hind limbs were specialized for an aërial life; the beak, though often toothed, was, in many forms, encased in horn; the neck was long and the skull, firm and rounded, with large orbits, strongly resembled that of the birds. Though the pelvis and hind limbs were like those of lizards, the shoulder-girdle with its keeled sternum and wing-supporting bones were remarkably avian. In the vital organization, also, a remarkable approach to the birds was made. The optic lobes were pressed below the cerebrum, and the circulatory system is believed to have been of warm blood, a supposition strengthened by the fact that the bones were provided with air-sacs, to which pneumatic ducts lead from the bronchial tubes, a respiratory system characteristic of only the warm-blooded birds. Feathers, however, nor any other means of protection, have not been found with the fossils. The wing consisted of a thin flap of skin, resembling that of the bats, and supported by an elongated ulnar finger. The several members of the order were of varying dimensions, ranging from the size of a sparrow to that of the condor. They were contemporaneous with the Dinosaurs, and formed a peculiar feature of the mesozoic landscape, as they flapped their wings on their journeys through the air, or as they perched themselves, comorant-like, along the shore, in company with the loon-like *Hesperornis*.

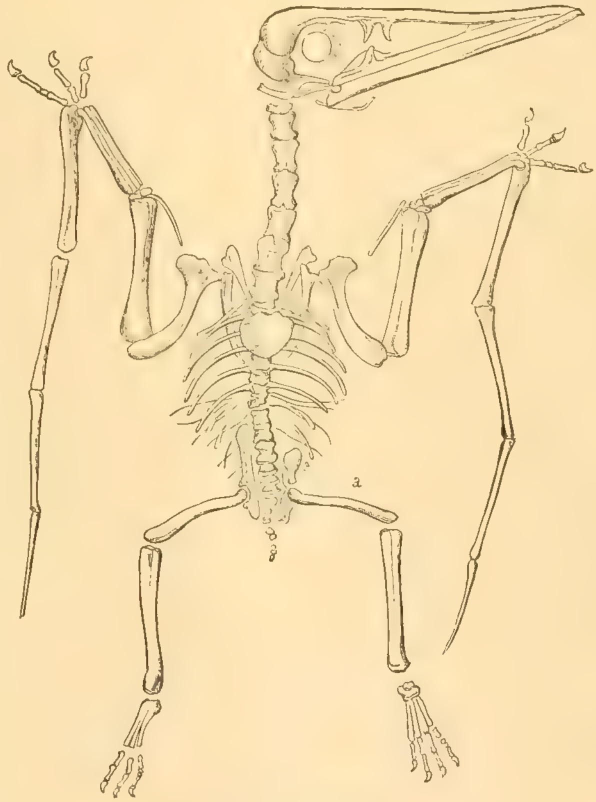


FIG. 270. — Pterodactyl.

The Pterodactyls had the jaws provided with teeth, planted some little distance from each other, and long and slender, which were probably of use in securing fish and smaller reptiles. The tail was short and insignificant, there being a regular decrease in the size of the vertebræ from the neck posteriorly. The centra were, like those of existing crocodiles, most lizards, and all ophidians, concave anteriorly and convex posteriorly. Though good flyers, the pterodactyls were able to make but poor progress on land, and probably crawled along, when obliged to, as do the bats of to-day. When resting, they probably suspended themselves to the cliffs, or to the branches of trees, the fingers seeming to indicate this habit. *Pterodactylus crassirostris* inhabited the lowlands of Germany, and was about a foot in length. Many other species are known from the European deposits. America can boast of but few species, but such as we have are of the largest size. *P. umbrosus*, from the Kansas chalk, had an alar extent of nearly twenty-five feet, while *P. occidentalis* measured eighteen. The *Pteranodons* differed from the pterodactyls in having the jaws destitute of teeth. They were, however, probably armed with horn.

Rhamphorhynchus is a genus of flying reptiles which inhabited Europe during the Jurassic period. The jaws were provided with long, sharp teeth, the eyes were large and well developed, and the flying membrane was supported, as in the pterodactyl, by the long ulnar fingers, and was of such a size as to easily support the body. The most peculiar feature, however, was the elongated tail, which equalled one of the wings in length. *R. phyllurus* carried at the end of this appendage a terminal, fan-like rudder, which was of use in directing the reptile's flight. Almost perfect remains have been found in the lithographic slate of Germany.

The European *Dimorphodon* had teeth of two kinds; those of the anterior portion of the jaw being large and long, while behind these was a series smaller and more compressed. The skull of *D. macronyx* was about eight inches long, and the wings expanded four feet. It is the oldest known form of the order.

The long series of cold-blooded vertebrates has been reviewed. Next come those whose blood is considerably warmer than the medium in which they live. The transition, however, is not abrupt. We have seen that some of the reptiles, especially the extinct forms, have avian tendencies. Among the birds, on the other hand, we shall see forms which have many reptilian features. In fact, the relationship existing between the reptiles and birds is closer than that between the reptiles and the forms with which, by the exigencies of publication, they are associated in this volume. By Huxley these two — Reptiles and Birds — are united in a group, Sauropsida.

HERMON C. BUMPUS.

INDEX.

SPECIAL NOTICE.

The date of issuance of the parts composing this volume are as follows: pages 1 to 96, June 2, 1885; pages 97 to 192, June 29, 1885; pages 193 to 288, August 12 1885; pages 289 to 468, August 20, 1885.